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Dodson

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(54) **SINGLE AND MULTI-STEP SNOWMAKING GUNS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

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(60) Provisional application No. 61/694,255, filed on Aug. 29, 2012, provisional application No. 61/694,250, filed on Aug. 29, 2012, provisional application No. 61/694,256, filed on Aug. 29, 2012, provisional application No. 61/694,262, filed on Aug. 29, 2012.

(51) **Int. Cl.**

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B05B 1/02	(2006.01)
B05B 1/04	(2006.01)
B05B 1/14	(2006.01)

(52) **U.S. Cl.**
CPC ***F25C 3/04*** (2013.01); ***B05B 1/02*** (2013.01); ***B05B 1/044*** (2013.01); ***B05B 1/14*** (2013.01)

(58) **Field of Classification Search**
CPC ... B05B 1/14; B05B 1/044; B05B 1/02; F23C 3/04
USPC 239/14.1, 14.2, 419.5, 423, 424, 425.5, 239/428.5, 433, 543, 544, 548, 550
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,385,218 A *	1/1995	Migliori	F15B 15/225	91/23
5,884,841 A *	3/1999	Ratnik	F25C 3/04	239/14.2
7,290,722 B1 *	11/2007	Ewald	F25C 3/04	239/14.1
9,170,041 B2 *	10/2015	Dodson	F25C 3/04	
2011/0049258 A1 *	3/2011	Lehner	F25C 3/04	239/14.2
2011/0174895 A1 *	7/2011	Ratnik	F25C 3/04	239/14.2

* cited by examiner

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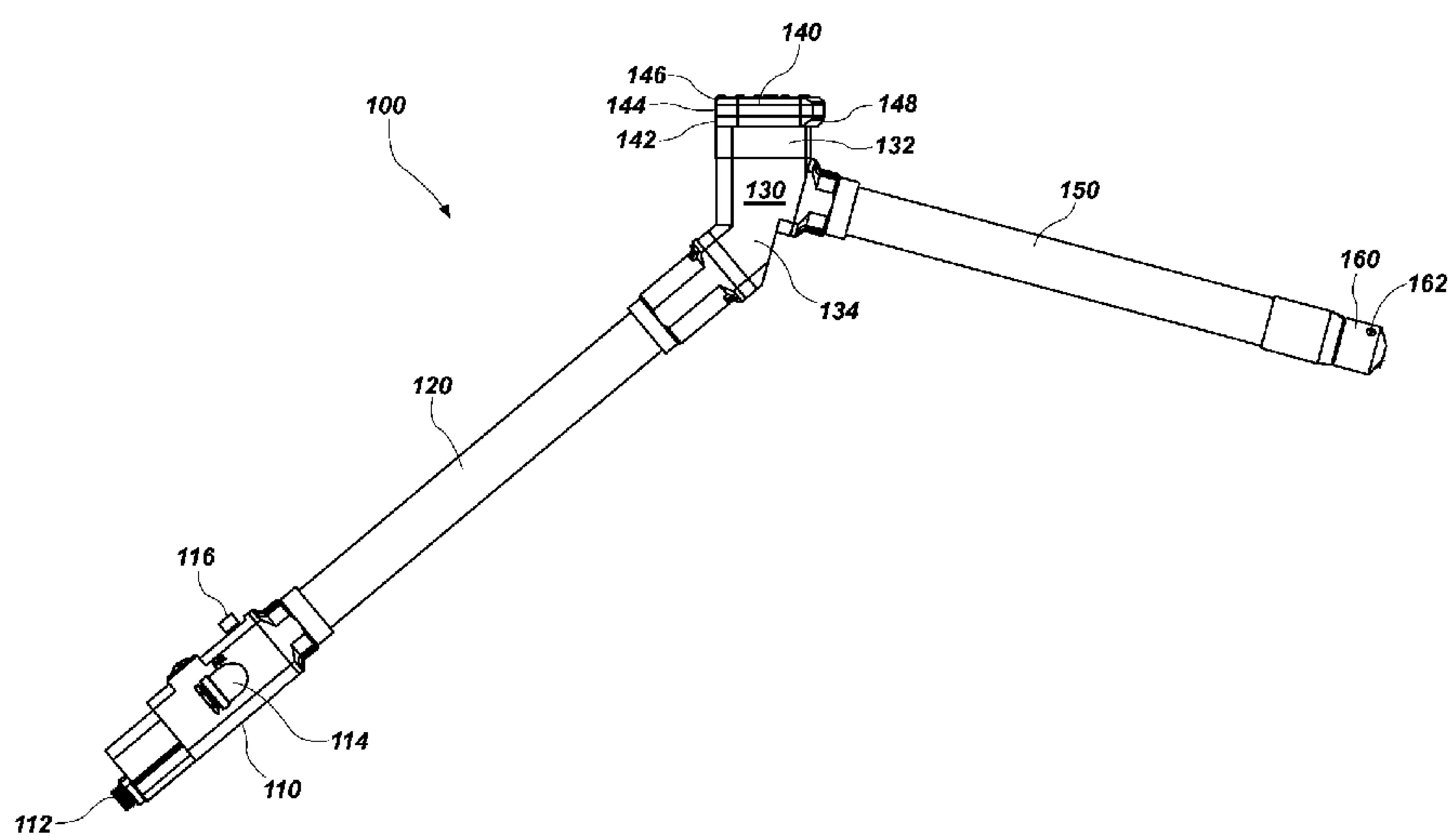
(57) **ABSTRACT**

Various embodiments of multi-step snowmaking guns are disclosed. More particularly, embodiments of a six-step, a four-step and a single step snowmaking gun are disclosed. Embodiments of the multi-step snowmaking guns may generally characterized by having a bottom manifold connected to a main mast, which is connected to a nozzle manifold, which in turn may be connected to a multi-step fluid nozzle. Embodiments of the multi-step snowmaking guns may further be generally characterized as having a nucleator head connected to a nucleator mast which is in turn also connected to the nozzle manifold.

20 Claims, 20 Drawing Sheets



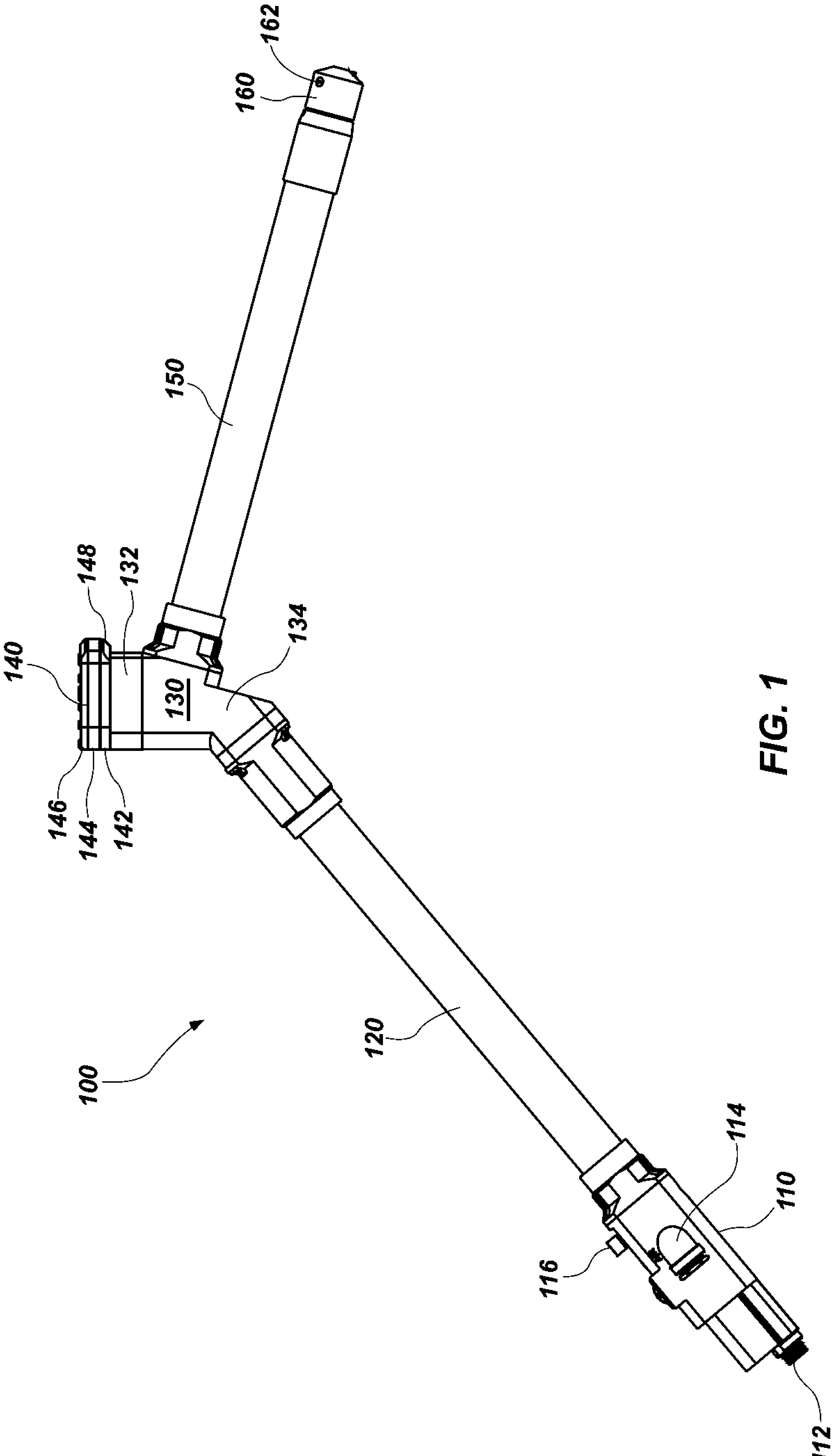

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FIG. 1

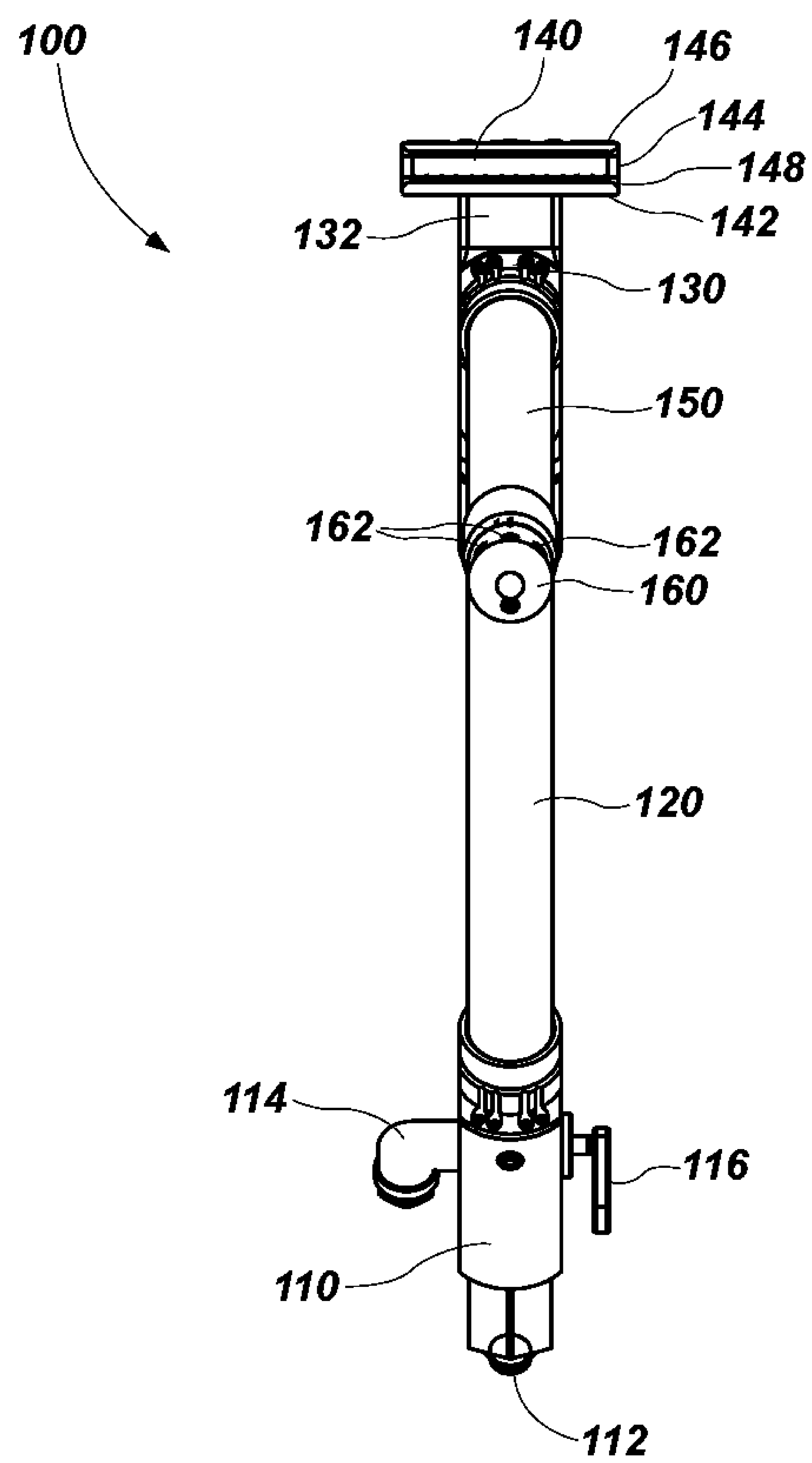
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FIG. 2

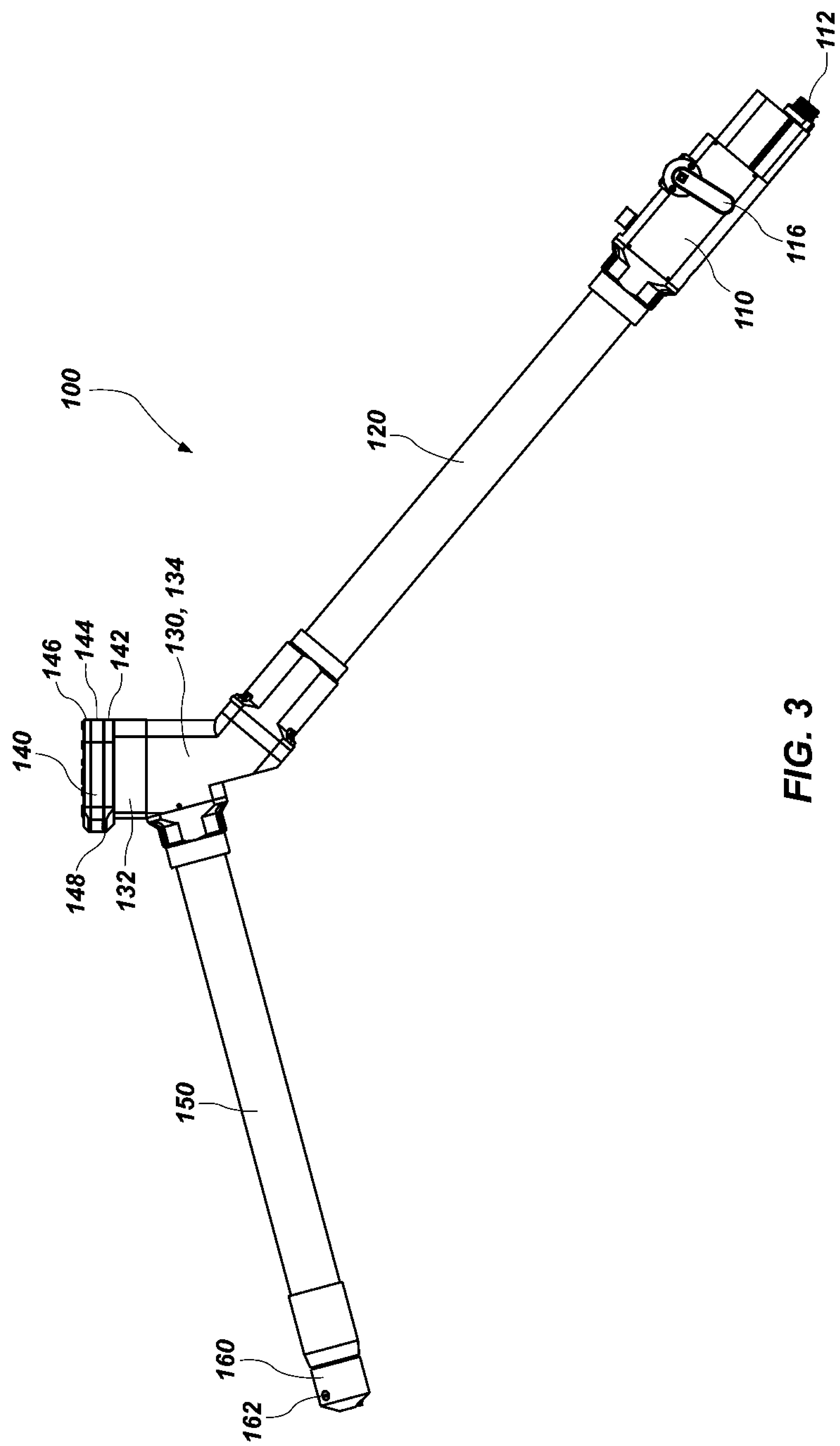


FIG. 3

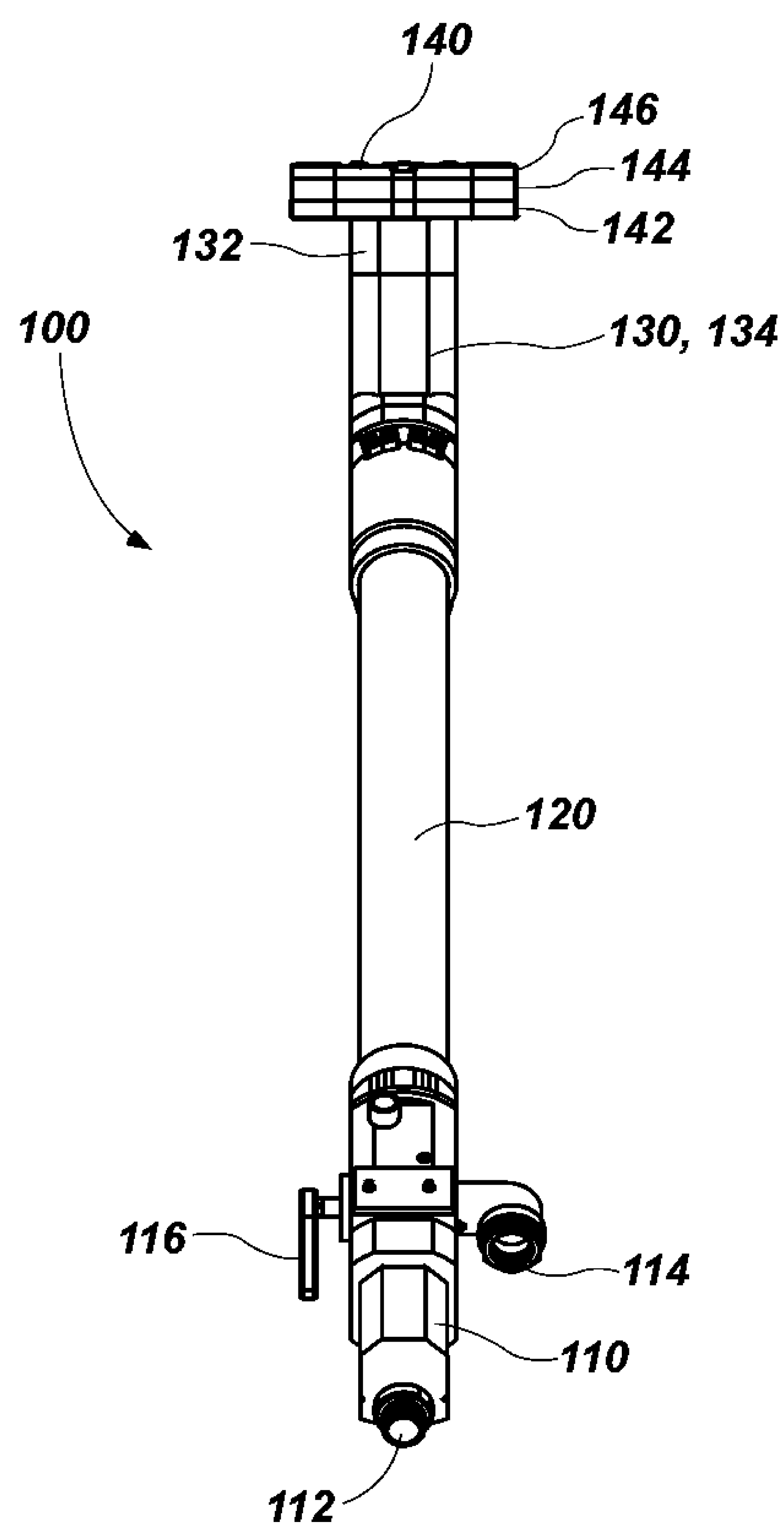


FIG. 4

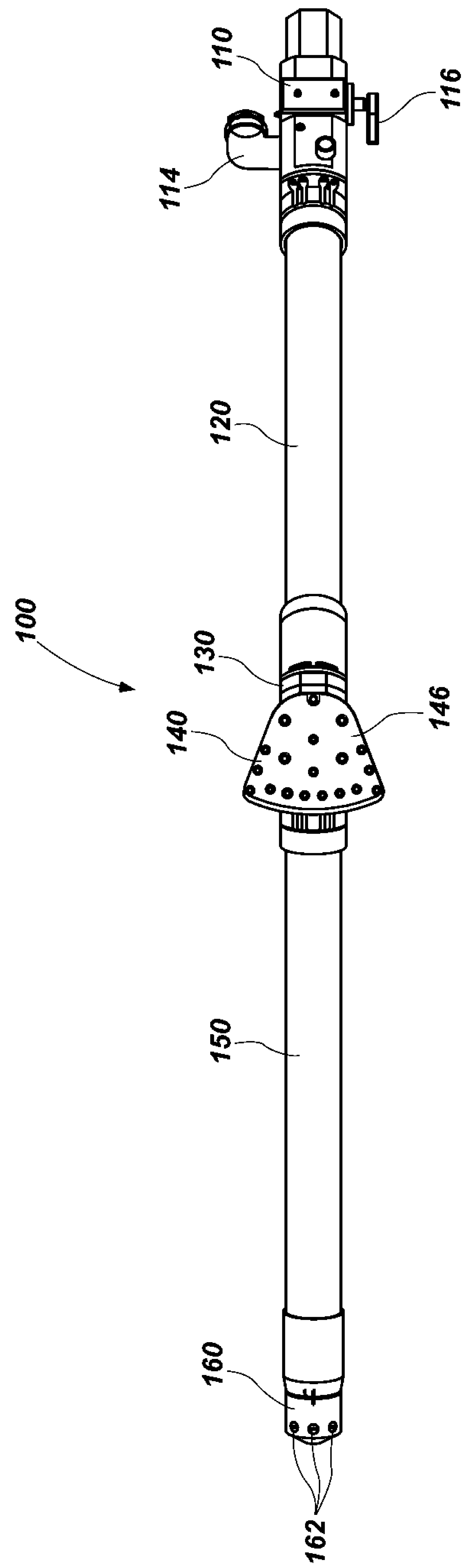


FIG. 5

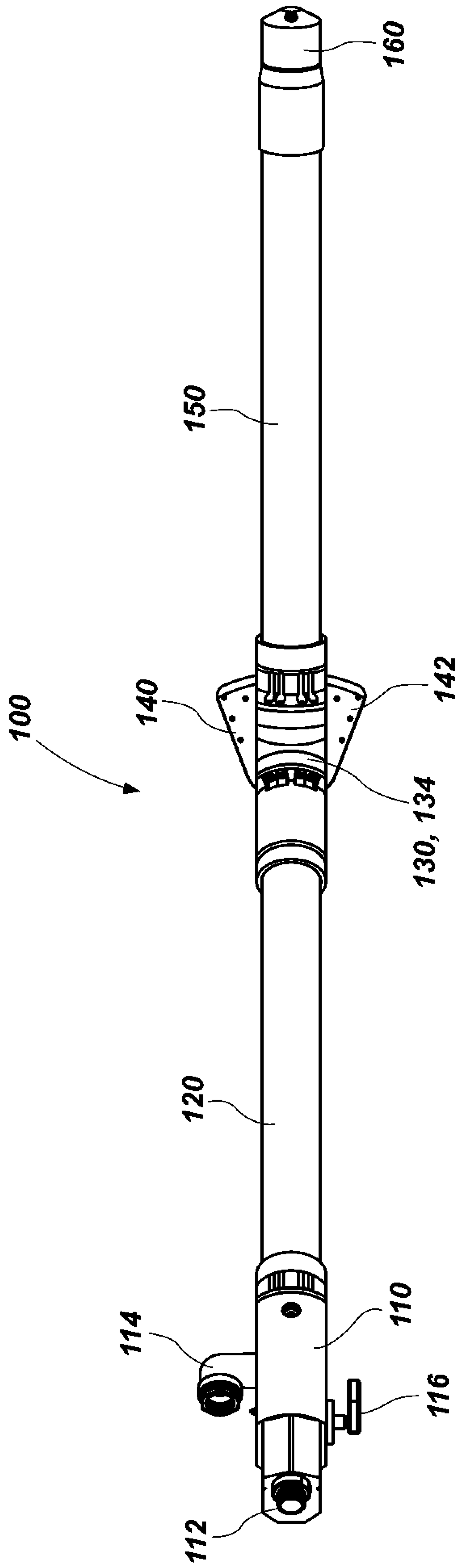


FIG. 6

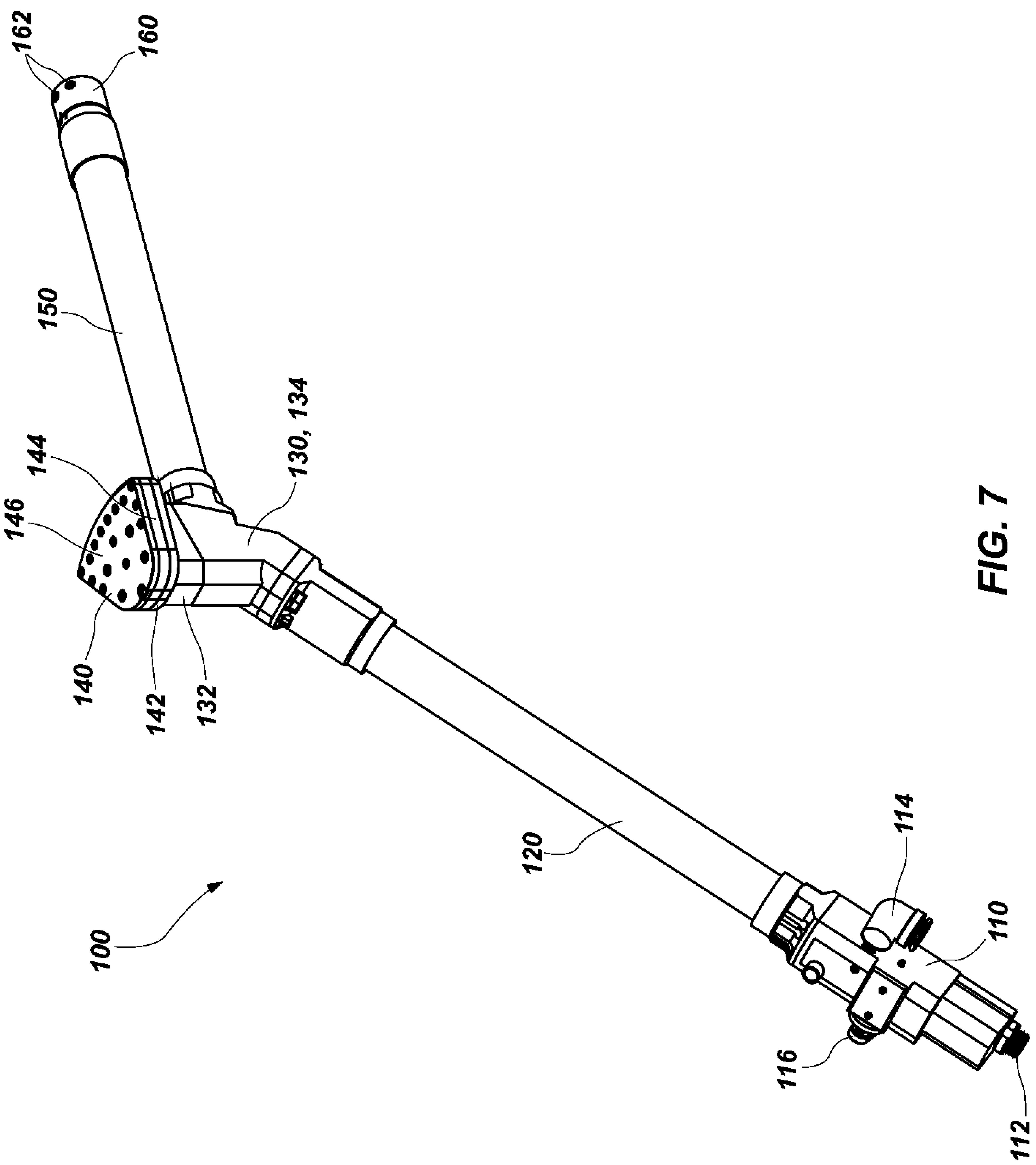


FIG. 7

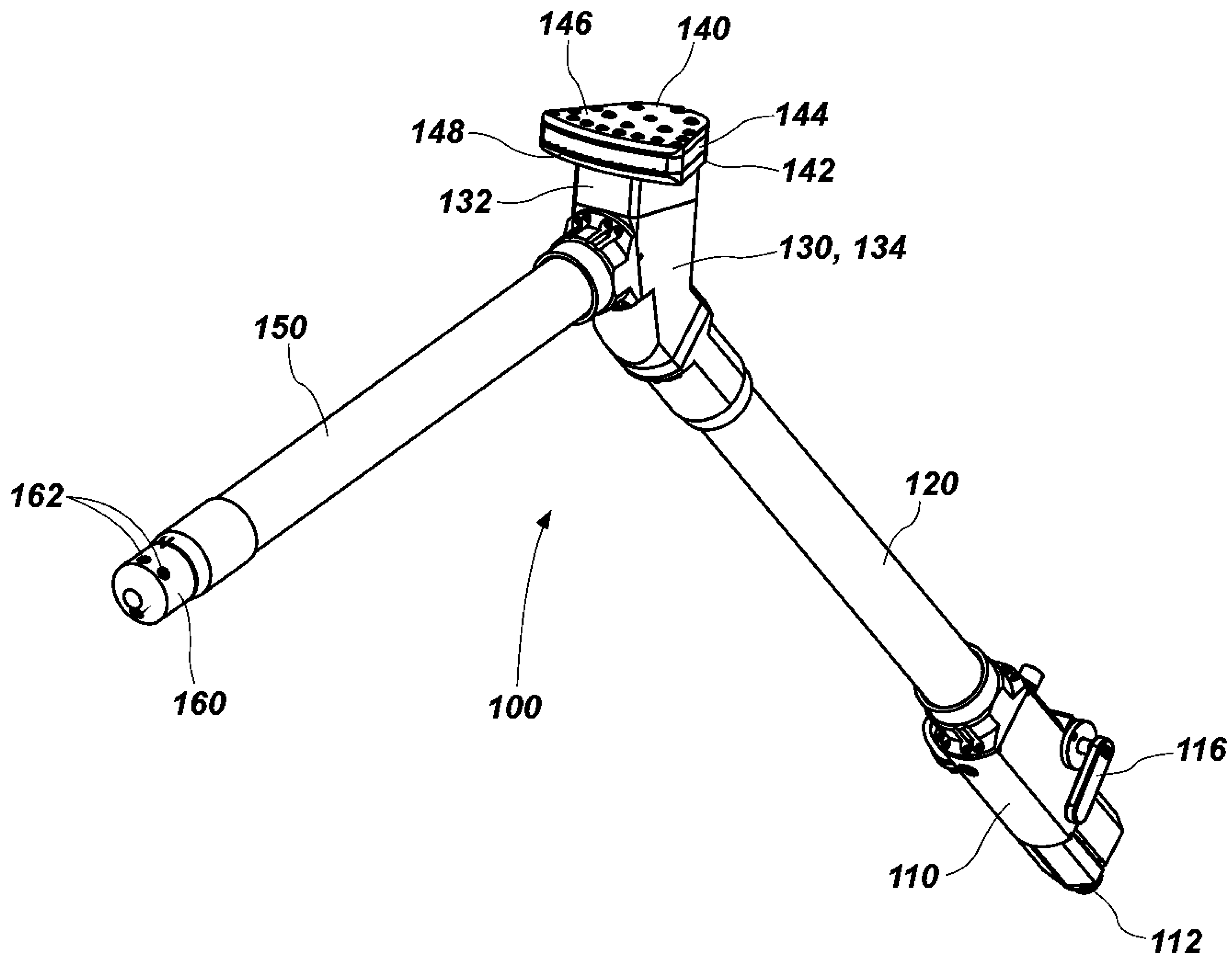


FIG. 8

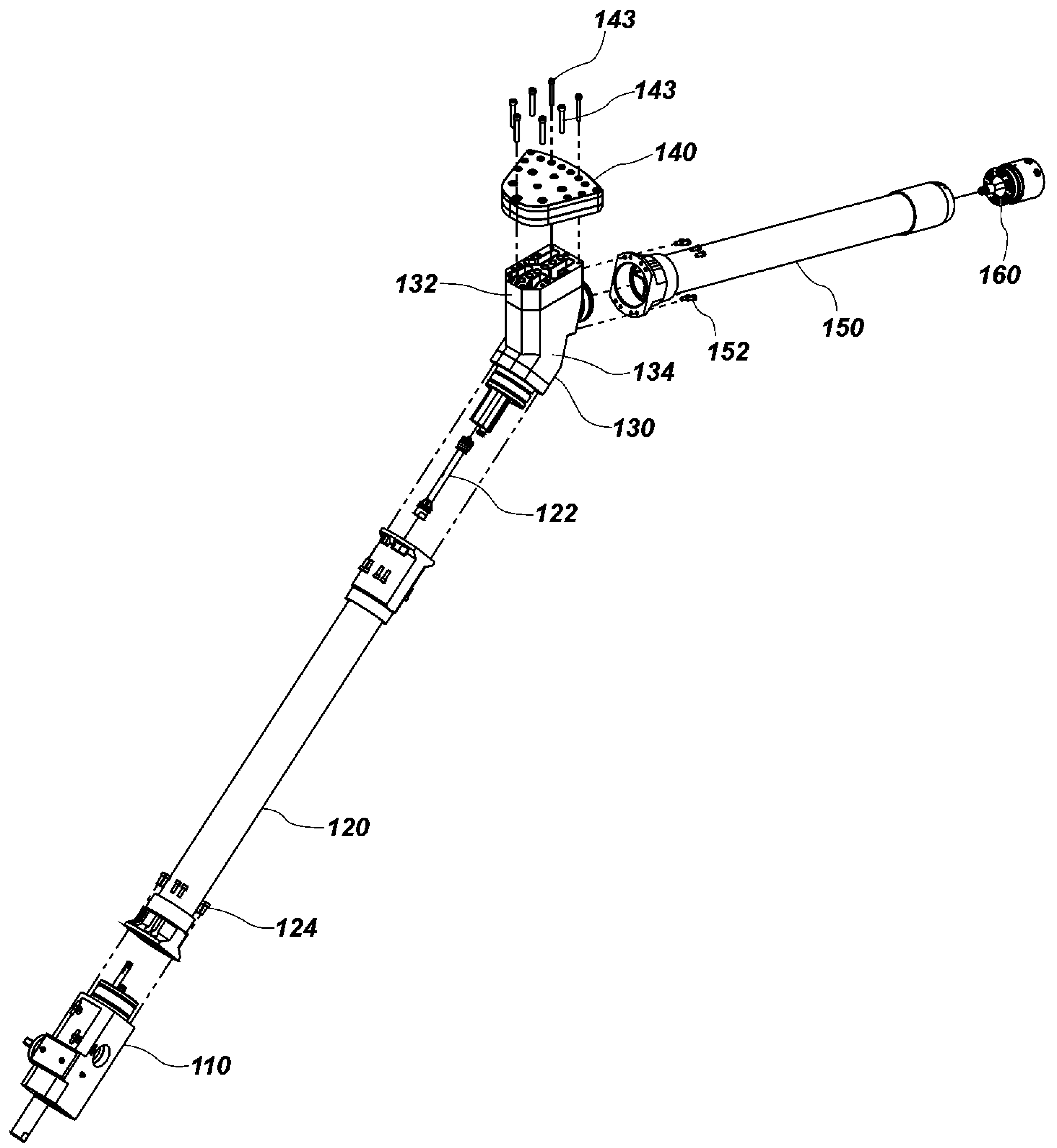


FIG. 9

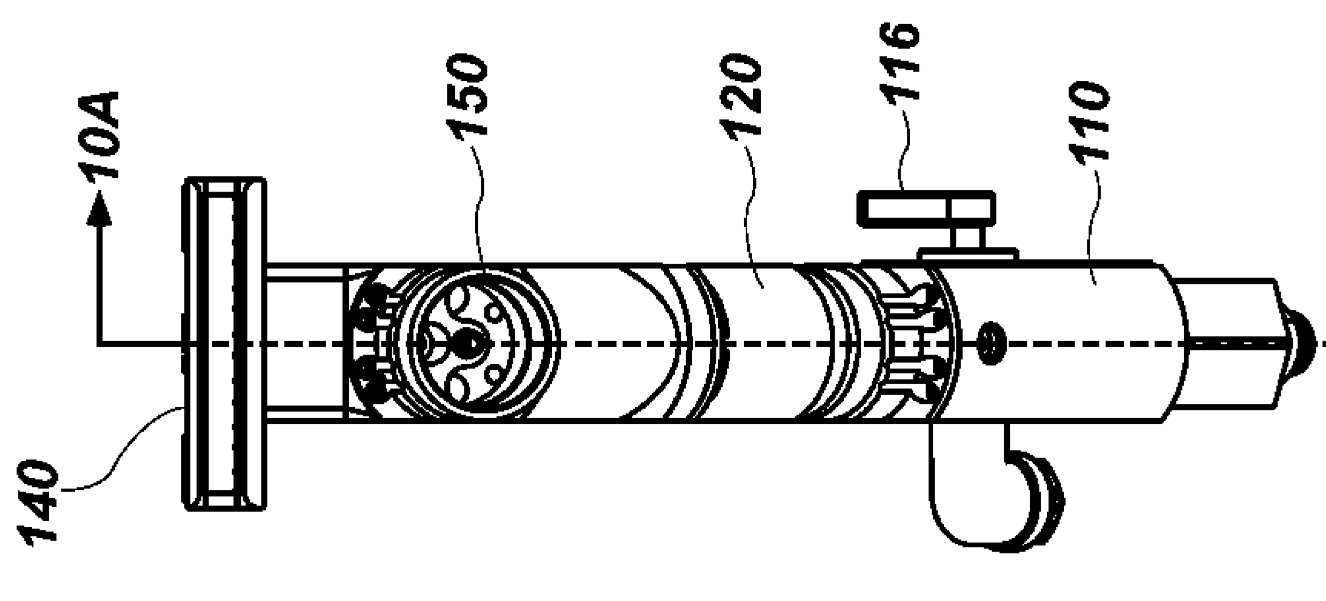


FIG. 10B

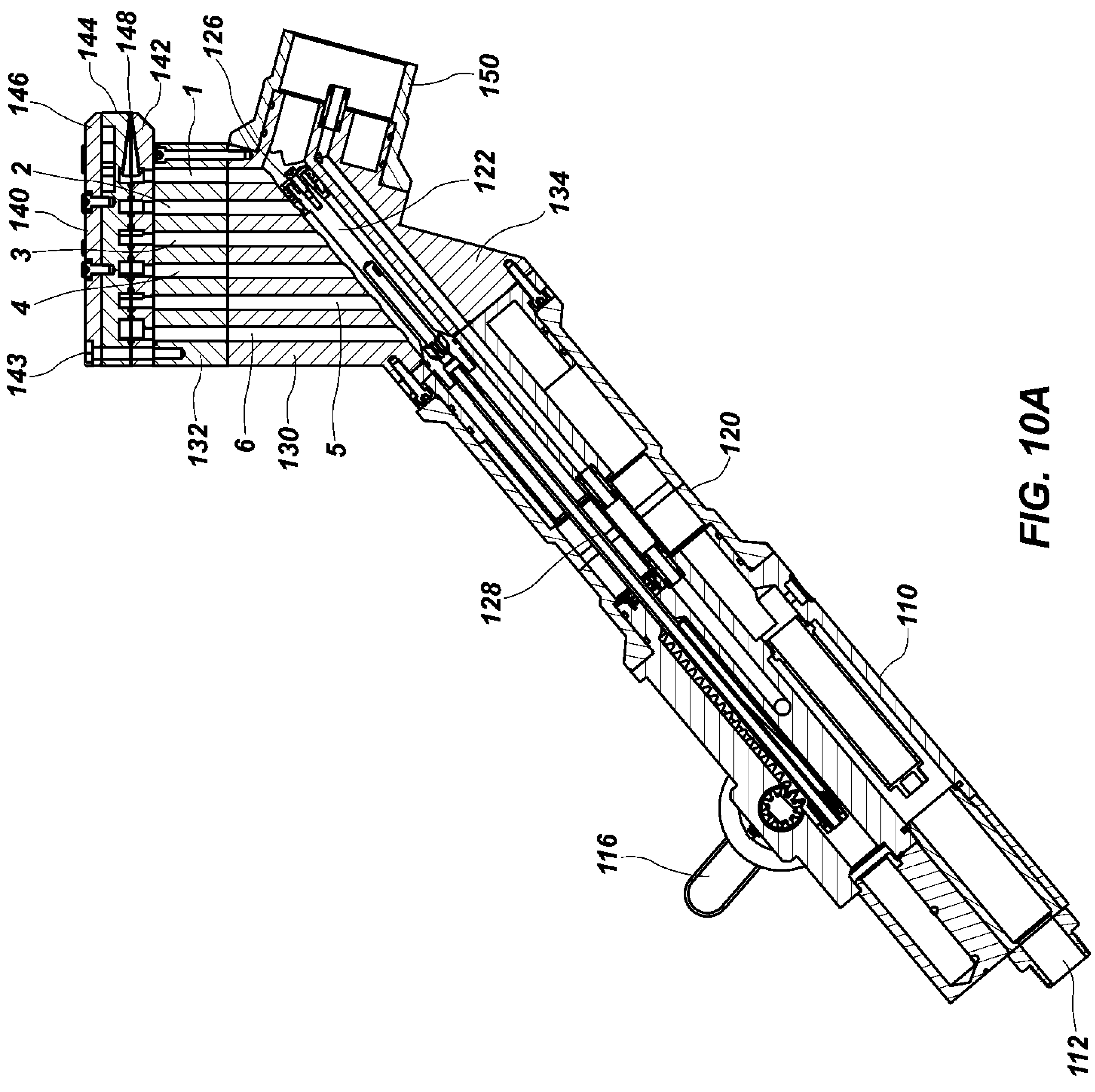


FIG. 10A

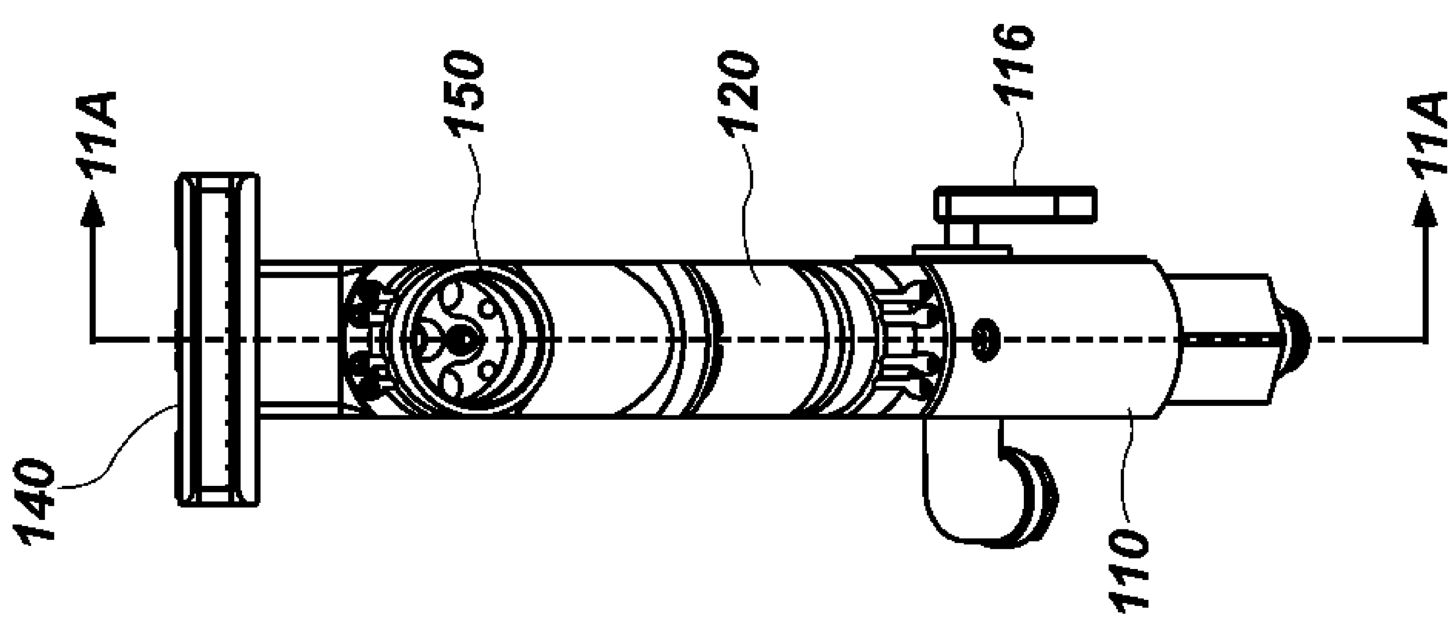


FIG. 11B

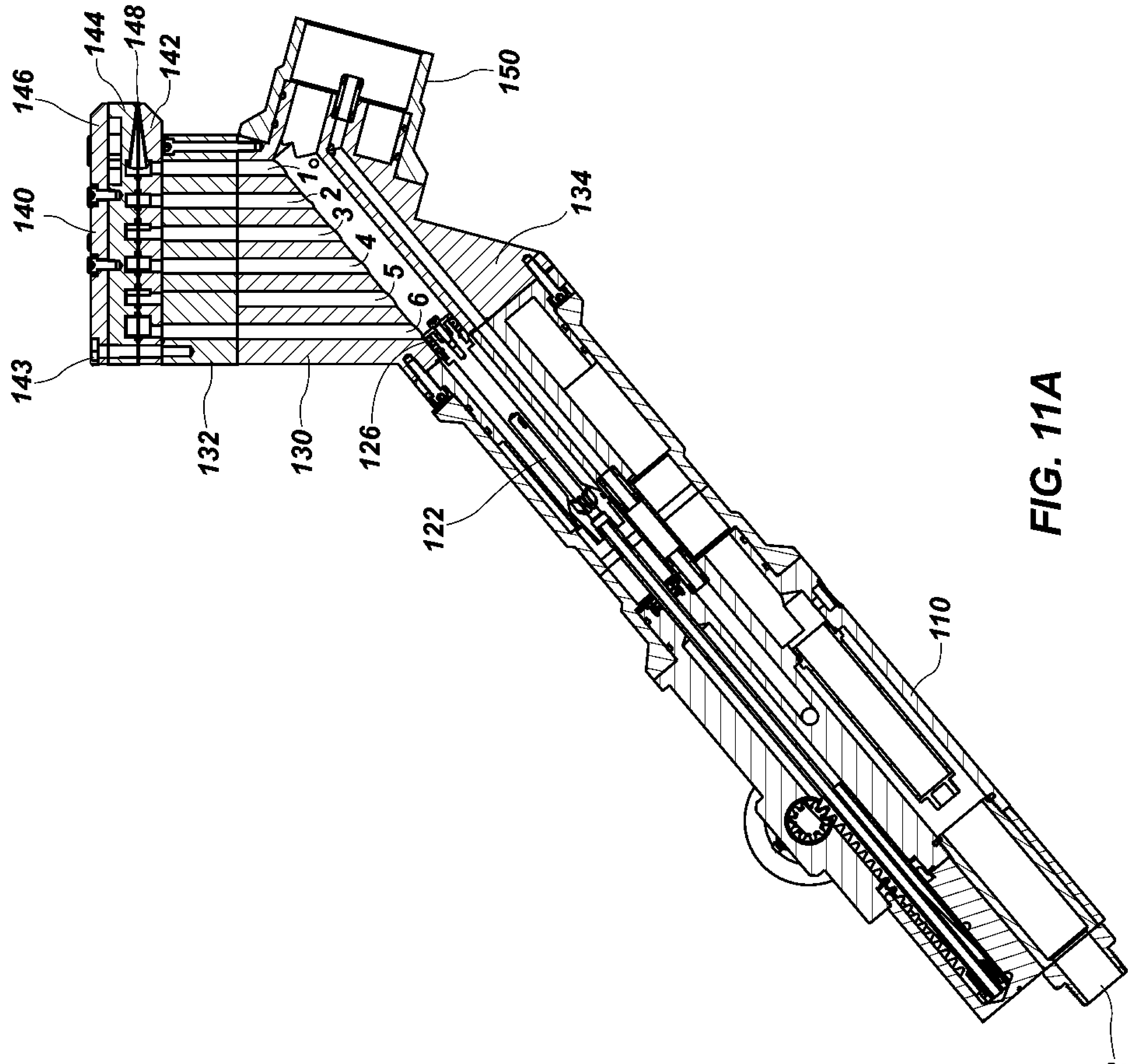


FIG. 11A

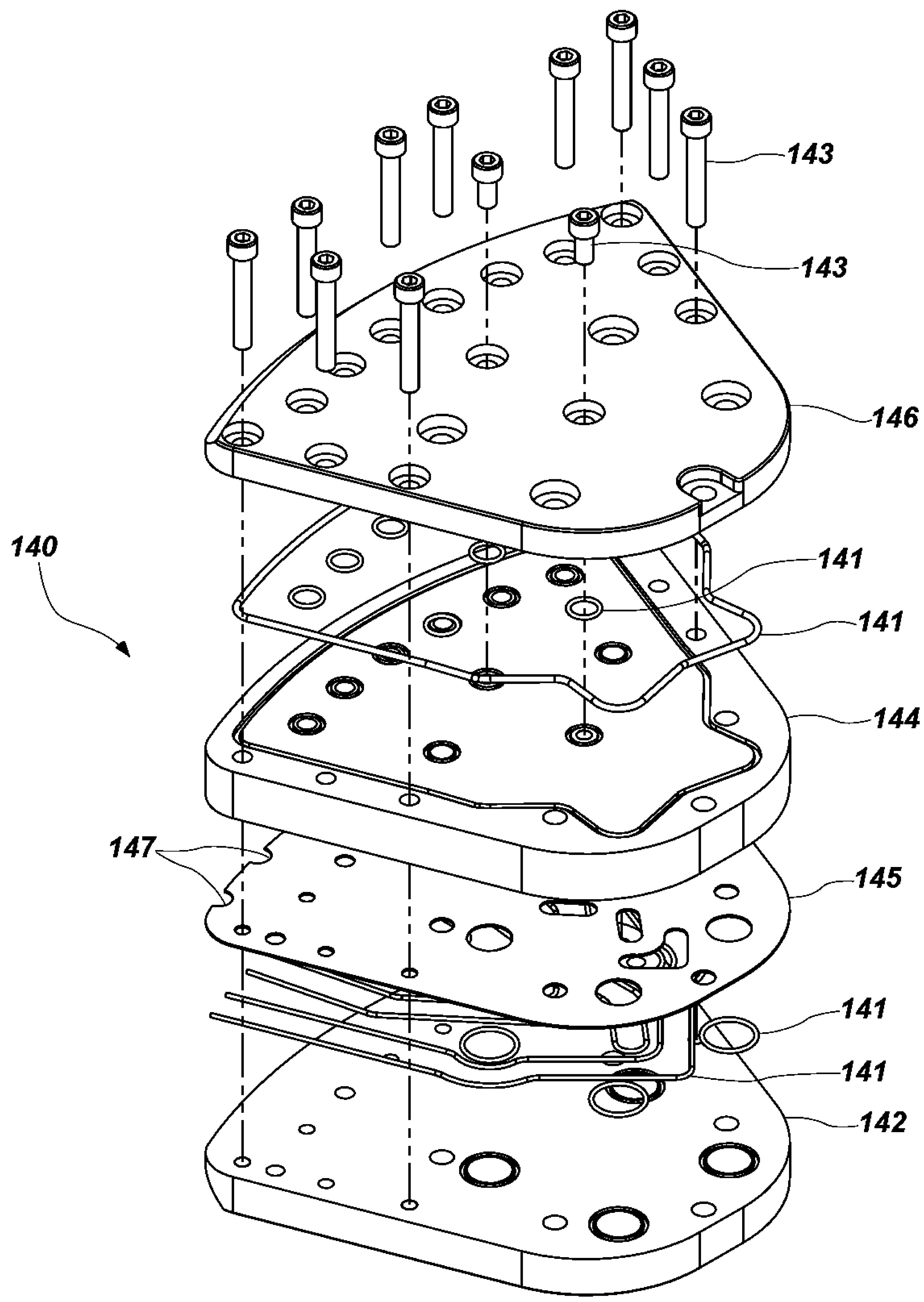
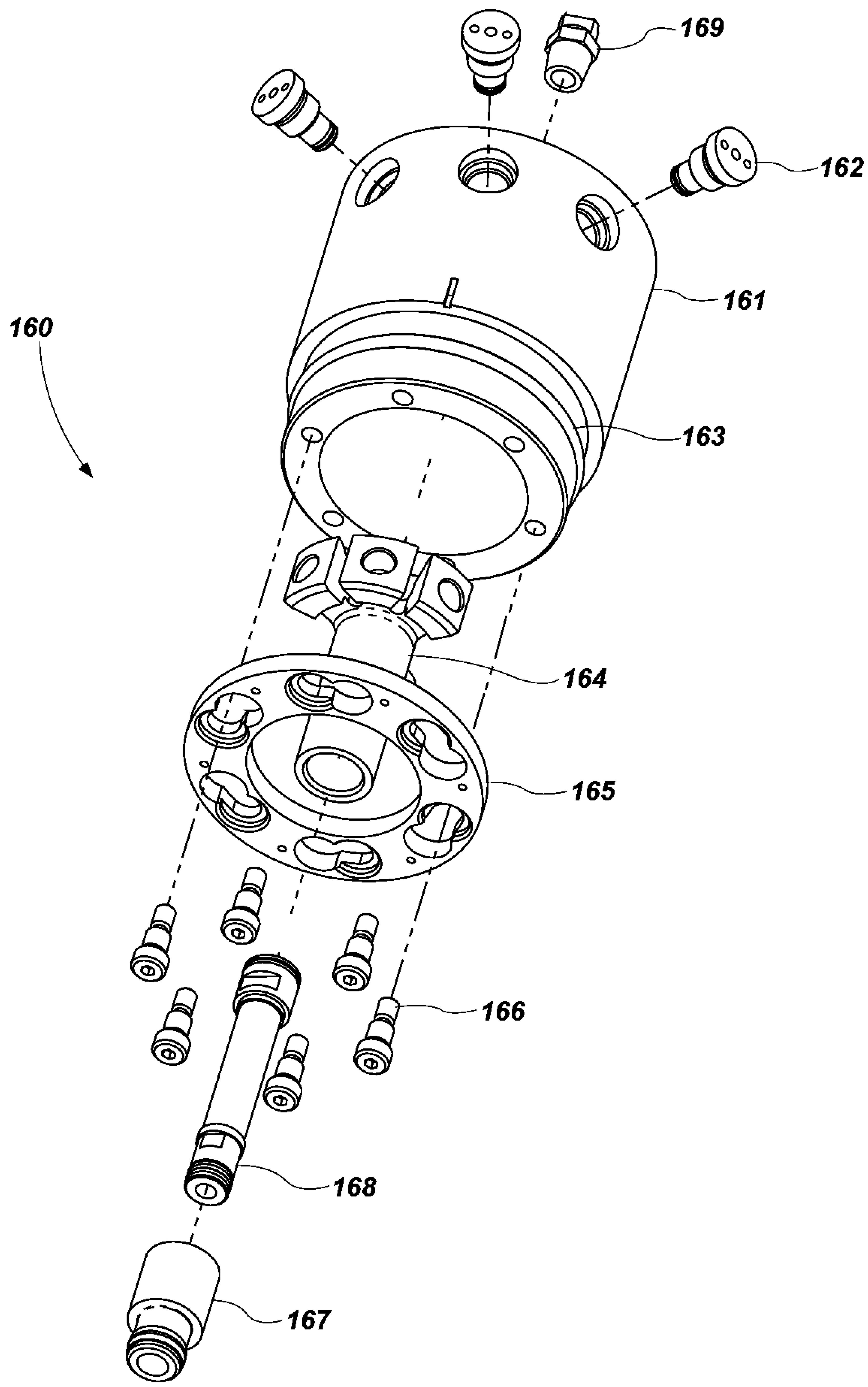


FIG. 12



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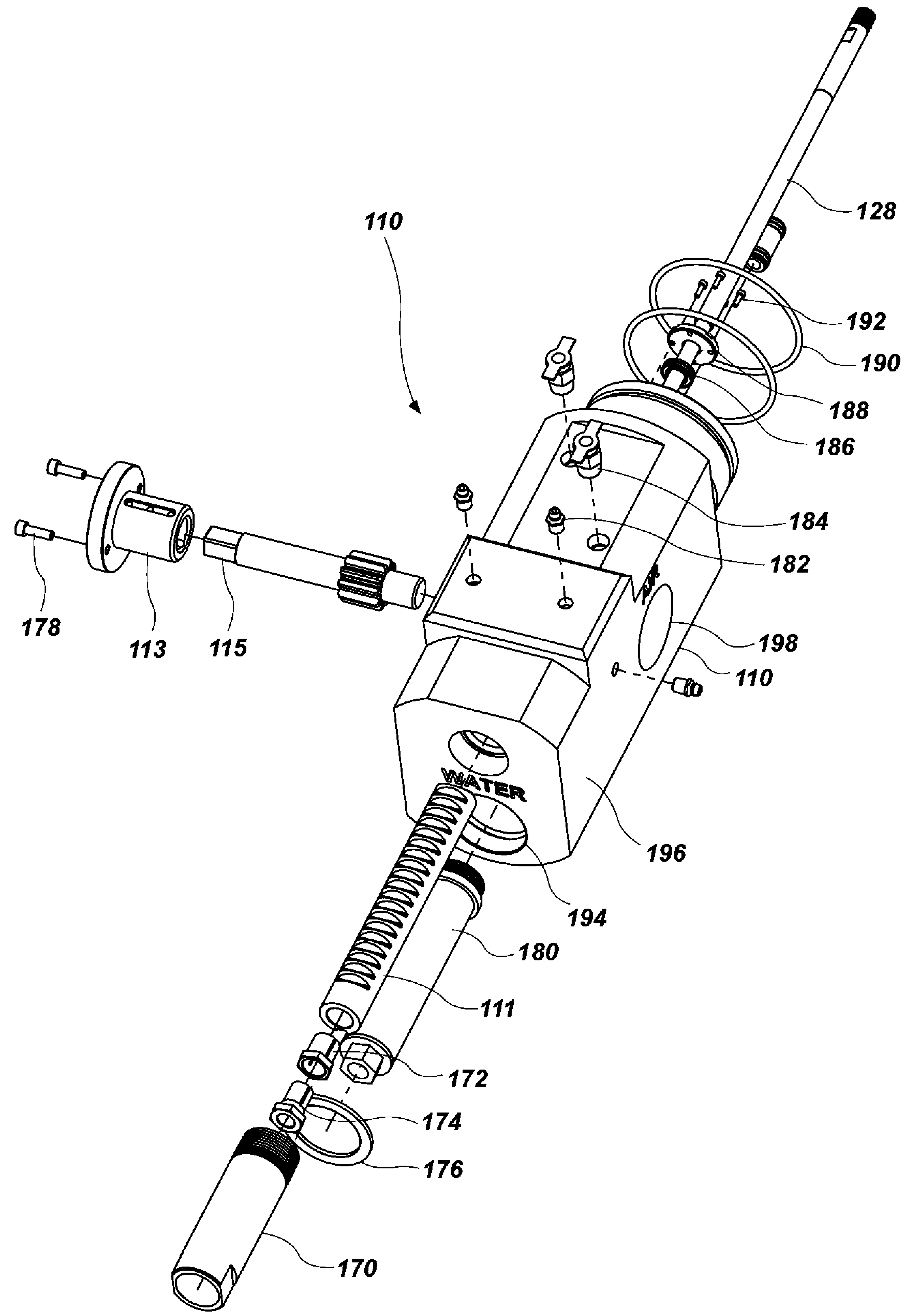
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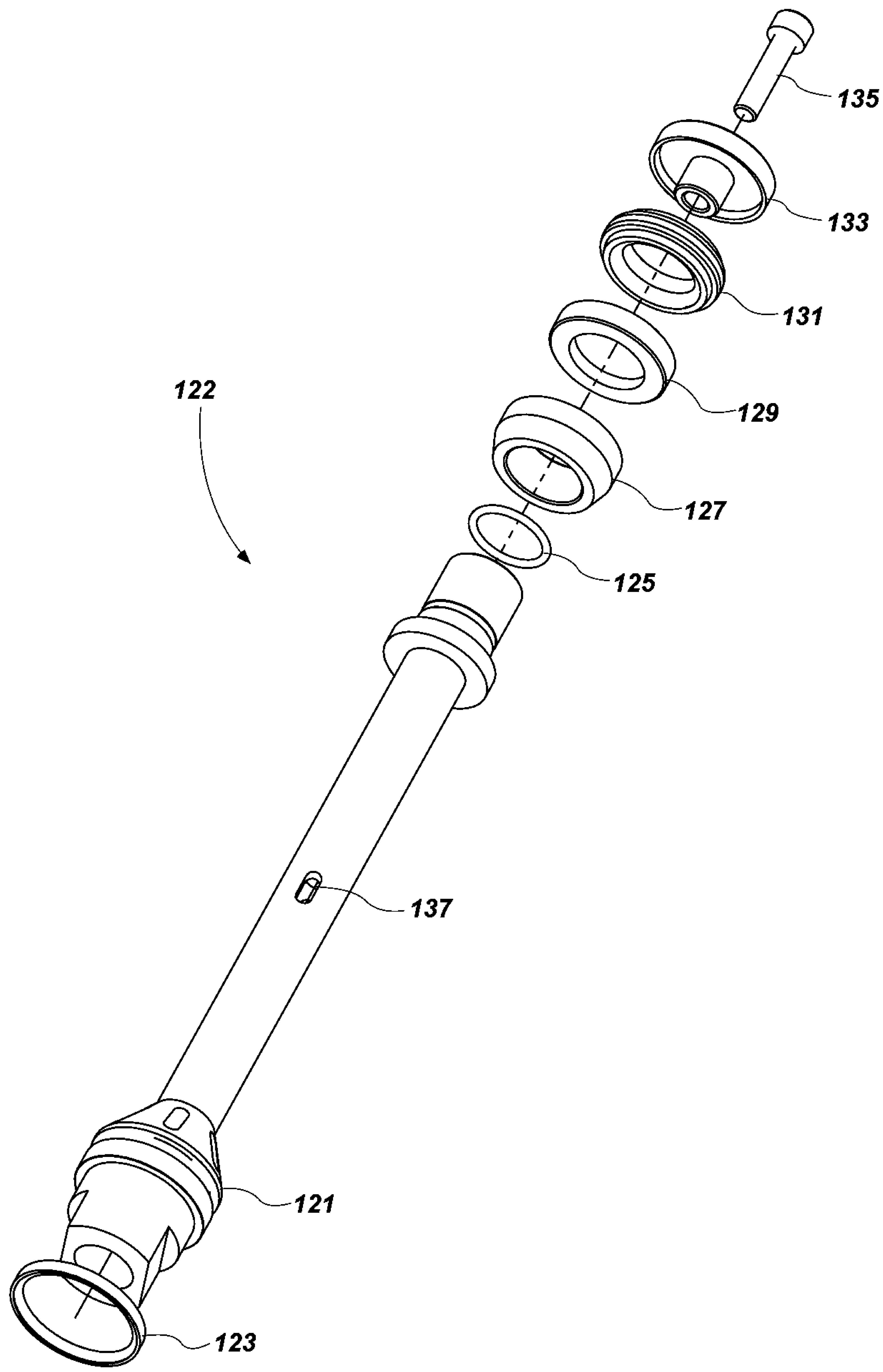
FIG. 14



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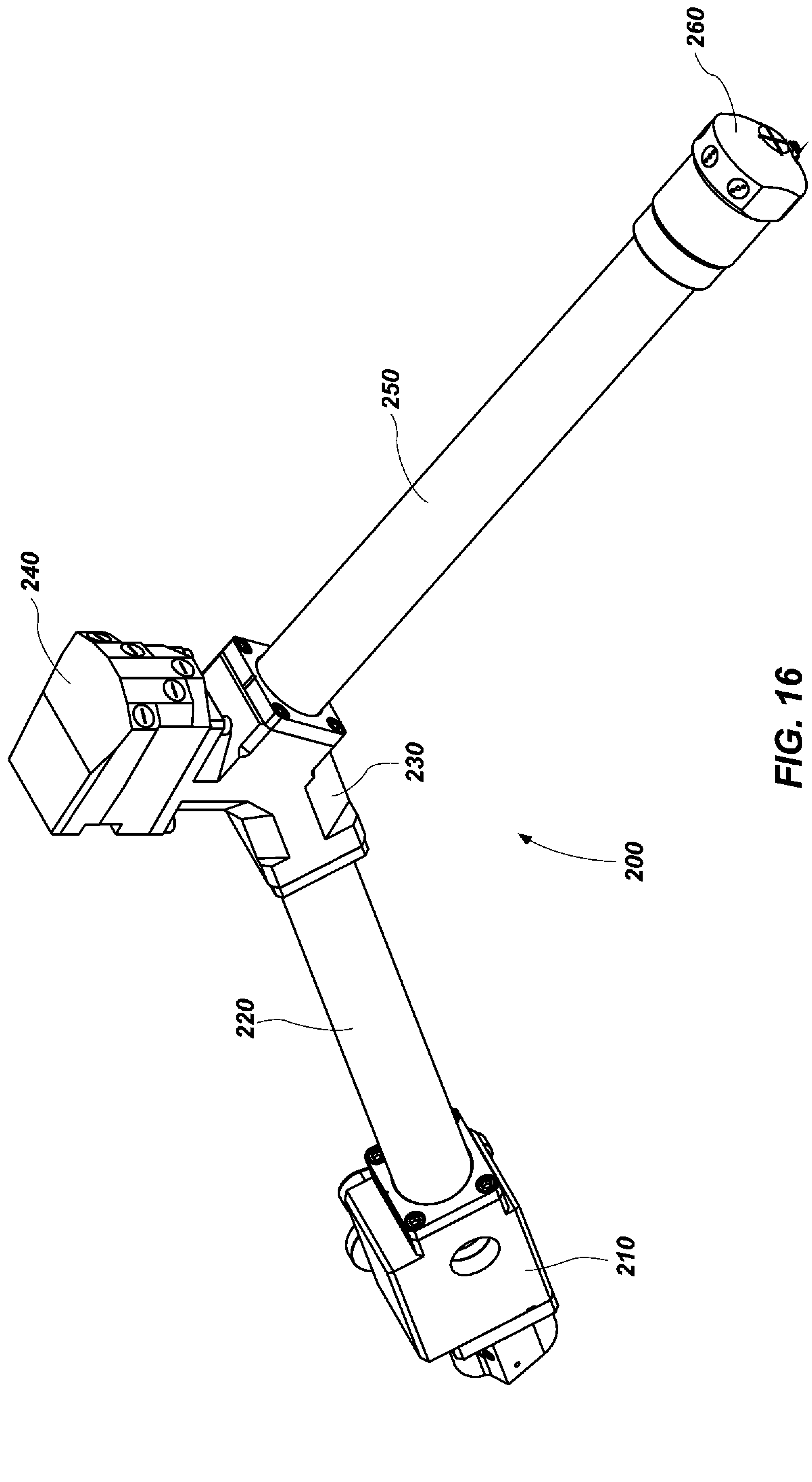

FIG. 16

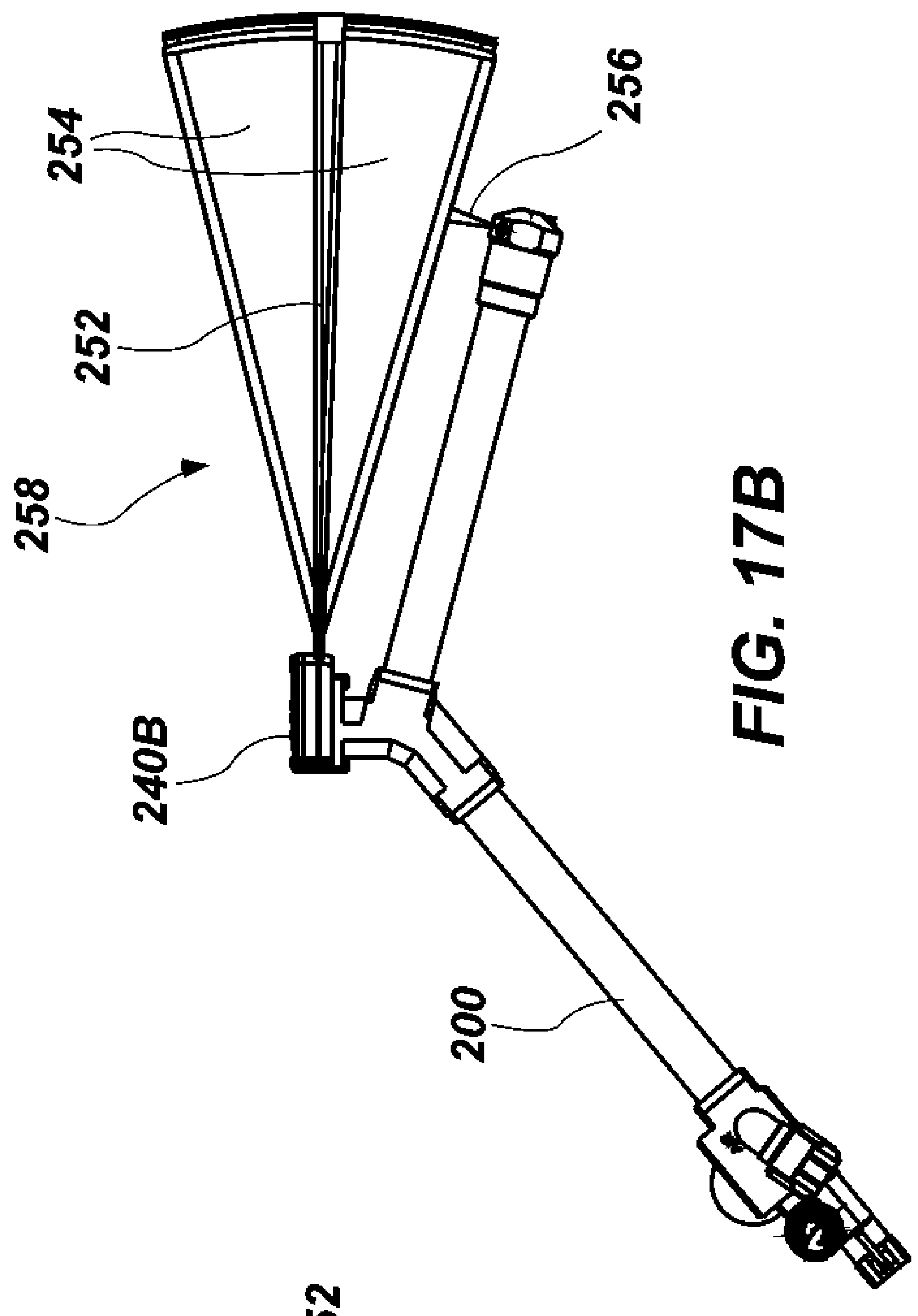

FIG. 17B

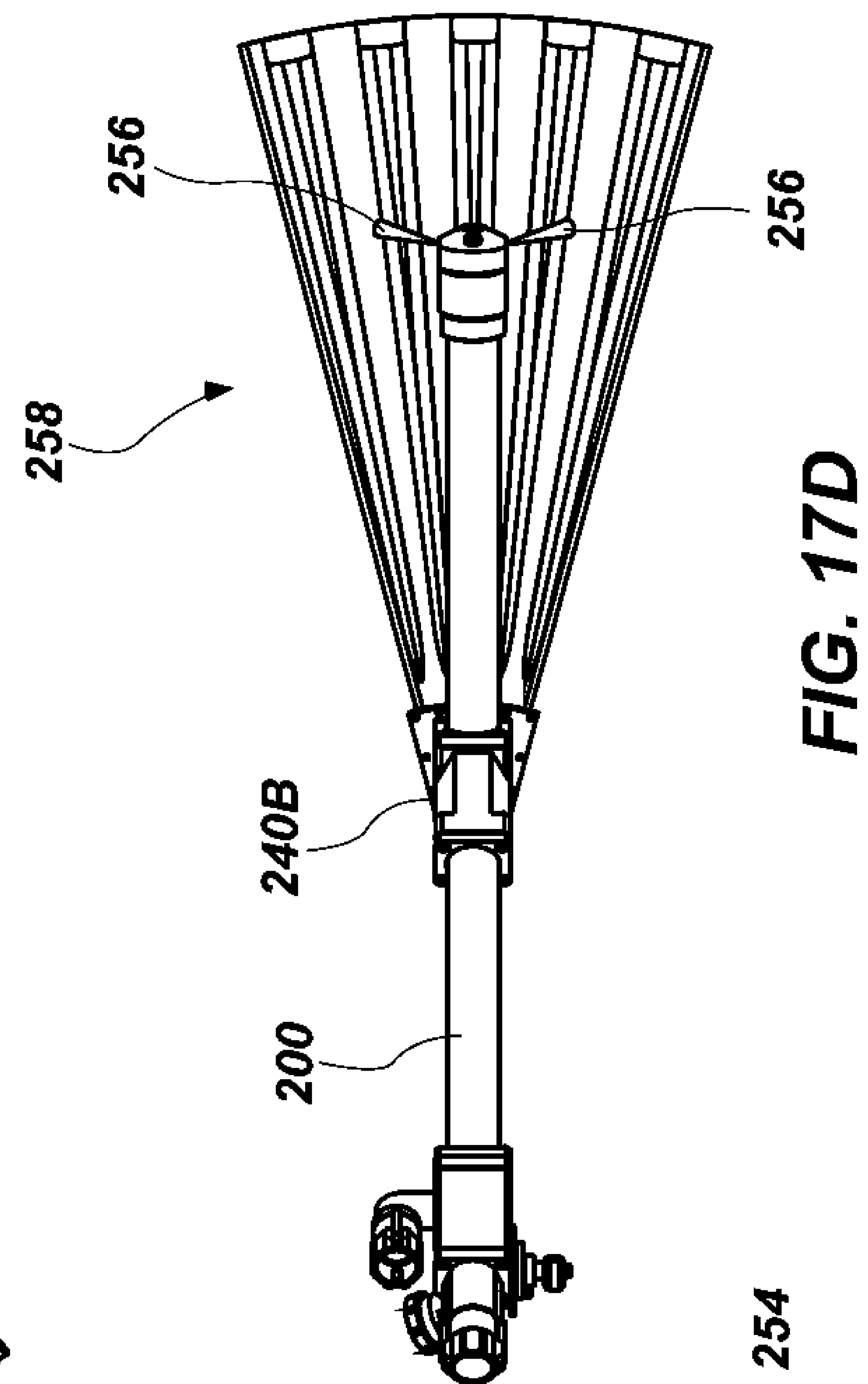

FIG. 17D

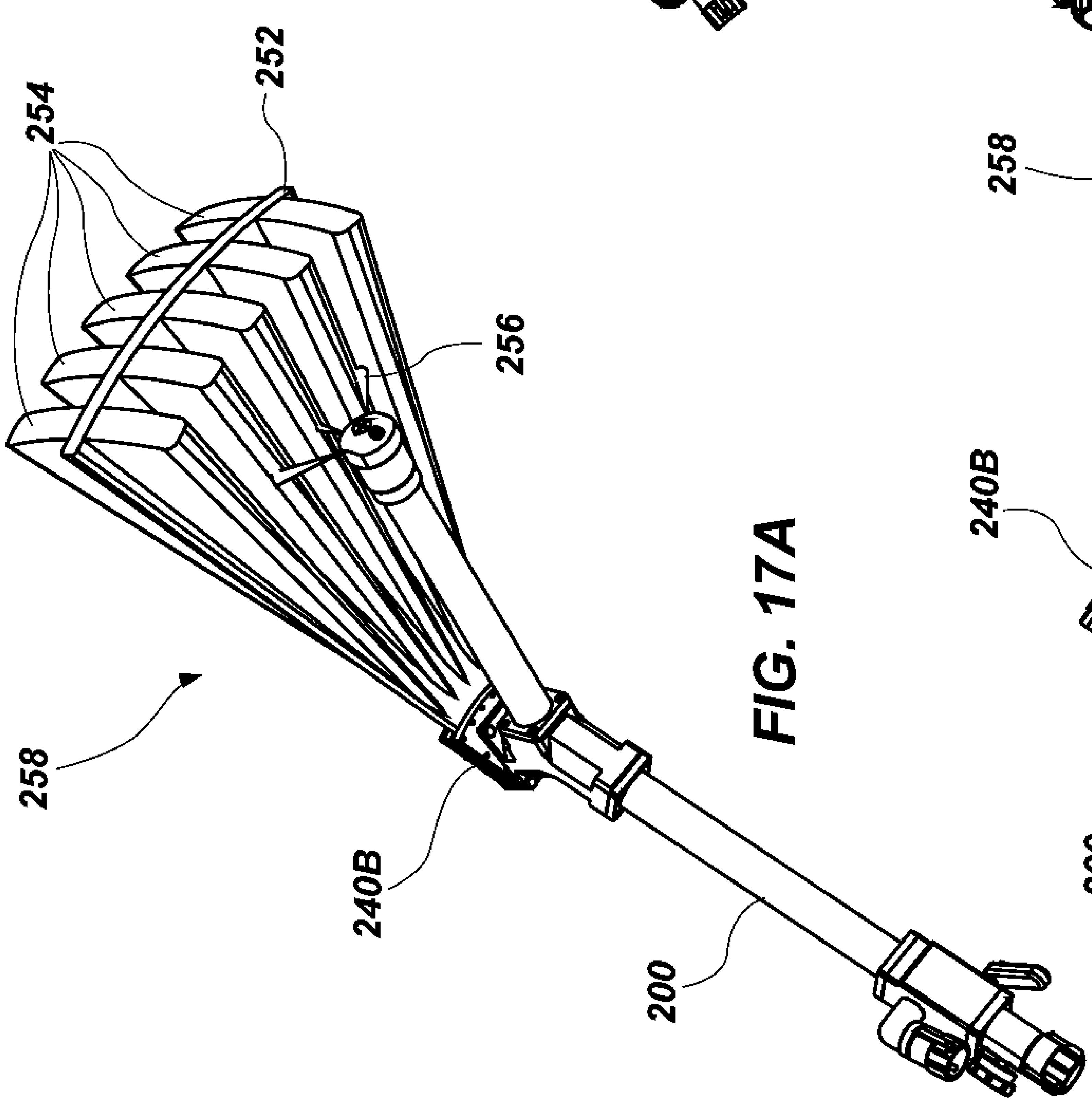

FIG. 17A

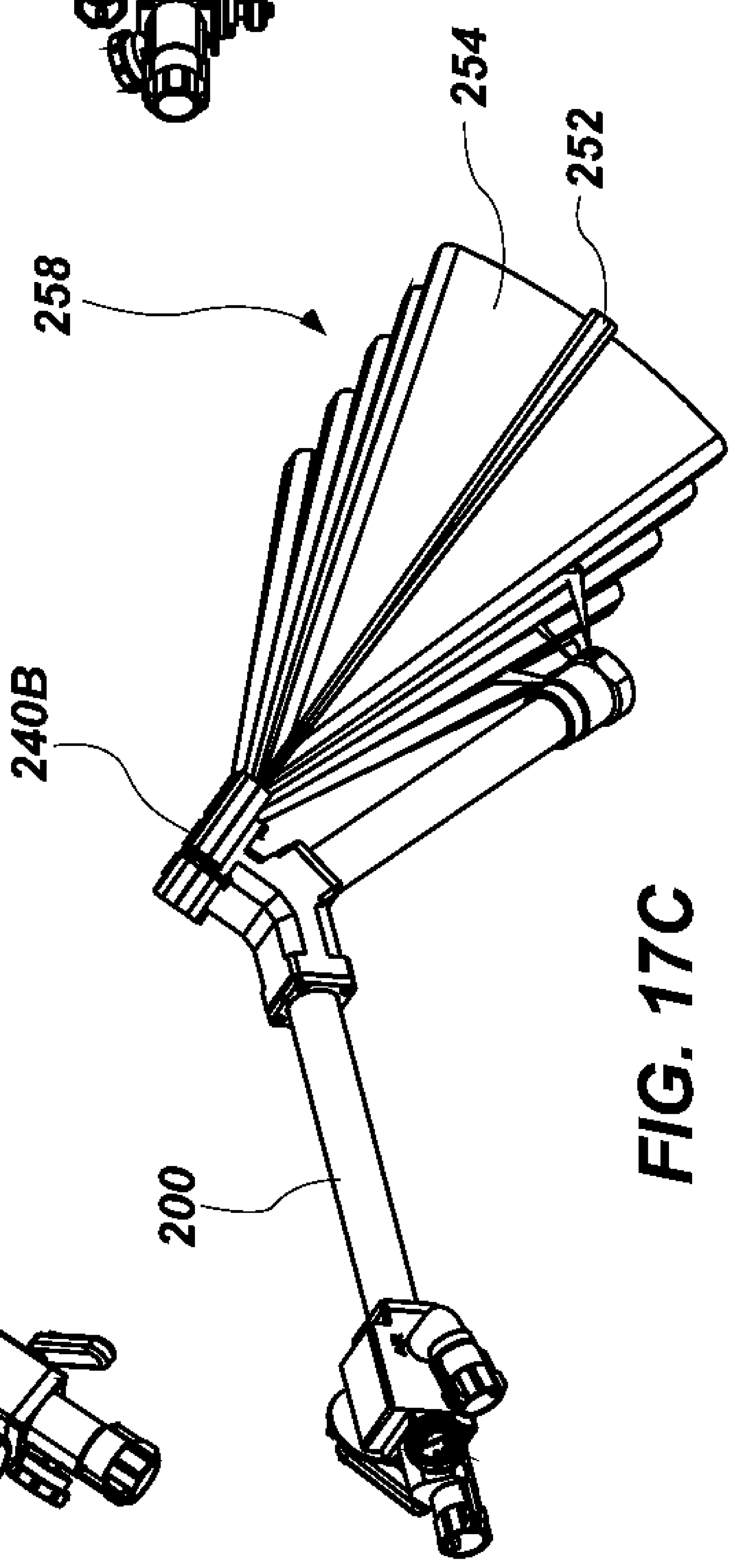

FIG. 17C

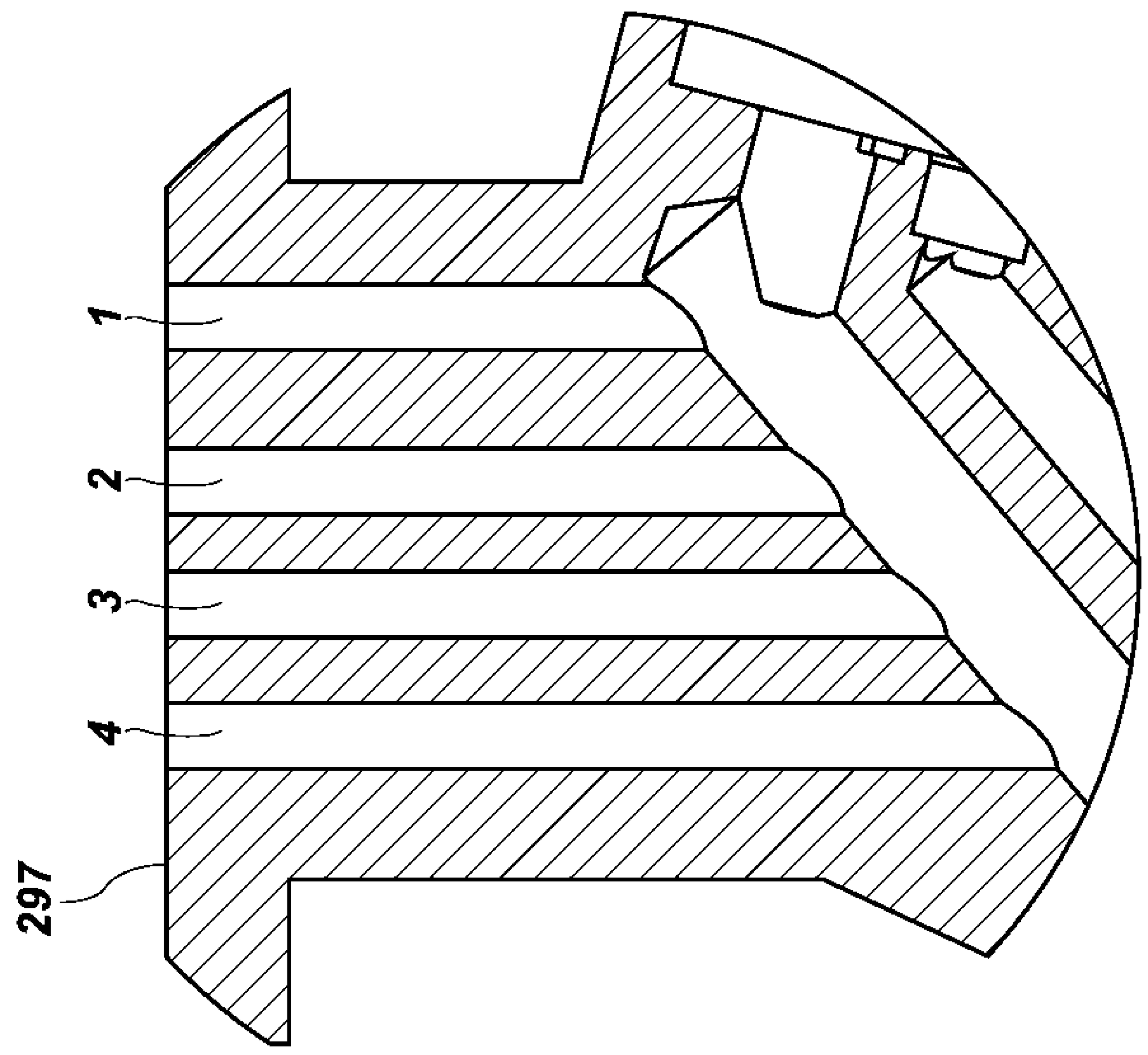

FIG. 18B

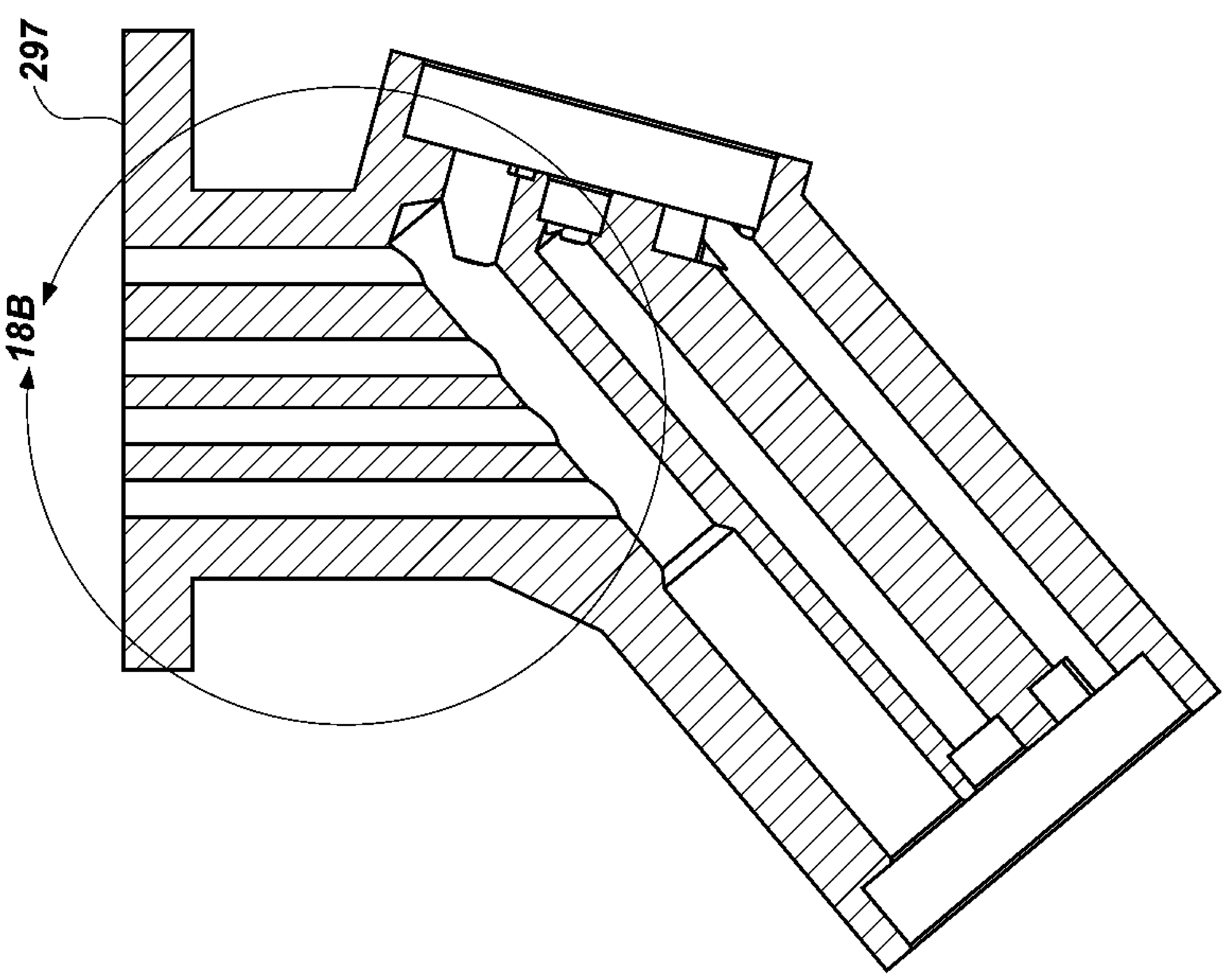

FIG. 18A

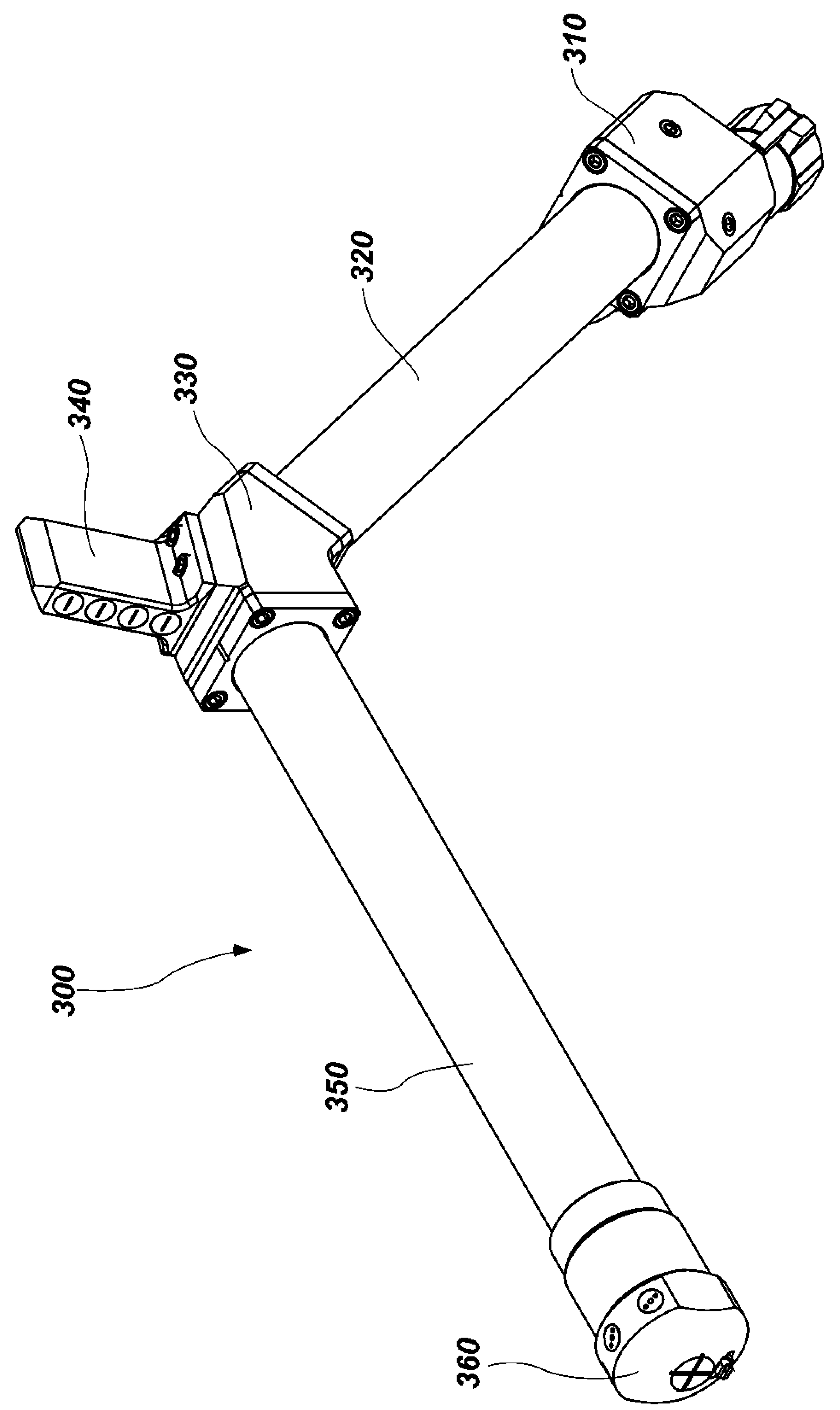

FIG. 19

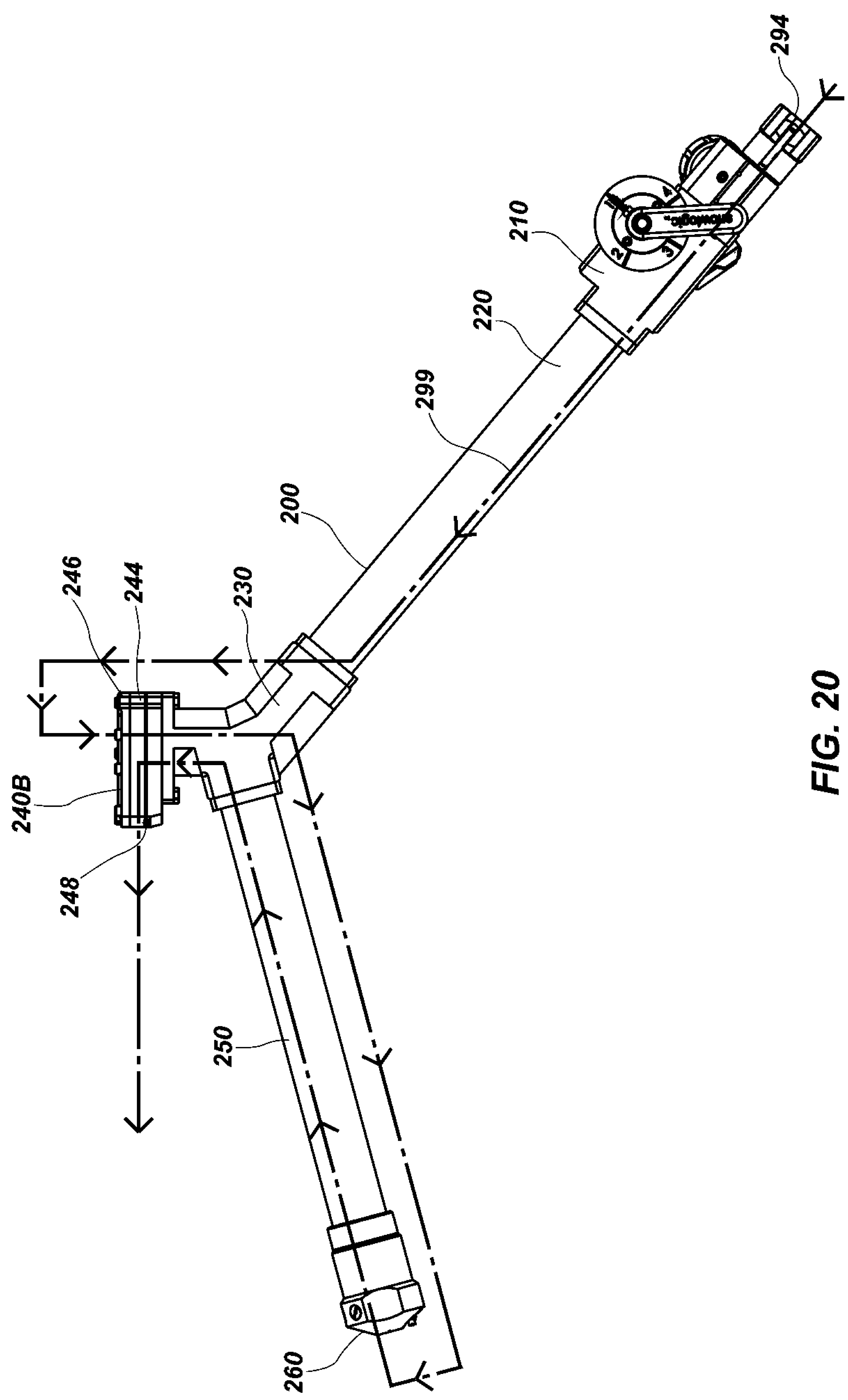

FIG. 20

SINGLE AND MULTI-STEP SNOWMAKING GUNS

CROSS-REFERENCE TO RELATED APPLICATIONS

This U.S. Continuation patent application claims the benefit and priority to U.S. Nonprovisional patent application Ser. No. 14/014,330, filed, Aug. 29, 2013, now U.S. Pat. No. 9,170,041, issued, Oct. 27, 2015, which in turn claims benefit and priority to U.S. Provisional Patent Application No. 61/694,255, filed, Aug. 29, 2012, titled: SIX-STEP SNOW-MAKING GUN, Aug. 29, 2013 and U.S. Provisional Patent Application No. 61/694,250, filed, Aug. 29, 2012, titled: FOUR-STEP SNOW-MAKING GUN, Aug. 29, 2013 and U.S. Provisional Patent Application No. 61/694, 256, filed, Aug. 29, 2012, titled: SINGLE-STEP SNOW-MAKING GUN, Aug. 29, 2013 and U.S. Provisional Patent Application No. 61/694,262, filed, Aug. 29, 2012, titled: MODULAR DUAL VECTOR FLUID SPRAY NOZZLES, Aug. 29, 2013. The contents of all of the aforementioned patent applications are expressly incorporated by reference, for all purposes, as if fully set forth herein.

This U.S. Continuation patent application is related to U.S. patent application Ser. No. 14/217,206, filed on Mar. 17, 2014, titled: NUCLEATOR FOR GENERATING ICE CRYSTALS FOR SEEDING WATER DROPLETS IN SNOW-MAKING SYSTEMS, pending. This U.S. Continuation patent application is further related to U.S. patent application Ser. No. 14/013,582, filed on Aug. 29, 2013, titled: MODULAR DUAL VECTOR FLUID SPRAY NOZZLES, pending. This U.S. Continuation patent application is further related to U.S. patent application Ser. No. 12/998,141, filed on Mar. 22, 2011, titled: FLAT JET FLUID NOZZLES WITH ADJUSTABLE DROPLET SIZE INCLUDING FIXED OR VARIABLE SPRAY ANGLE, now U.S. Pat. No. 8,534,577, issued Sep. 17, 2013, which is a National Stage of International Patent Application No. PCT/US2009/005345 filed on Sep. 25, 2009, titled: FLAT JET FLUID NOZZLES WITH ADJUSTABLE DROPLET SIZE INCLUDING FIXED OR VARIABLE SPRAY ANGLE, now expired, which in turn claims benefit and priority to Australian Provisional Patent Application No. 2008904999, filed on Sep. 25, 2008, titled "PLUMES", also expired. The contents of all of the aforementioned patent applications are expressly incorporated by reference, for all purposes, as if fully set forth herein.

Finally, this U.S. Continuation patent application is also related to U.S. Design patent application No. 29/430,677, filed on Aug. 29, 2012, titled: SIX-STEP SNOW-MAKING GUN, now U.S. Design Pat. No. D692,528, issued on Oct. 29, 2013, U.S. Design patent application No. 29/430,678, filed on Aug. 29, 2012, titled: FOUR-STEP SNOW-MAKING GUN, now U.S. Design Pat. No. D693,902, issued Nov. 19, 2013, and U.S. Design patent application No. 29/430, 679, filed on Aug. 29, 2012, titled: SINGLE-STEP SNOW-MAKING GUN, now U.S. Design Pat. No. D692,982, issued Nov. 5, 2013. The contents of all of the aforementioned design patents are also expressly incorporated by reference, for all purposes, as if fully set forth herein.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to snowmaking equipment. More particularly, this invention relates to single, four-step and six-step snowmaking guns particularly useful for producing snow at ski resorts and anywhere else that has sufficiently cold atmospheric conditions.

Description of Related Art

The production of artificial snow is well known in the art. Conventional snow guns or snow lances of various forms find application particularly in winter sports areas. According to one known method, a jet of ice nuclei, or seed crystals, is produced in a "nucleator nozzle" and is brought into contact with a jet composed of water droplets some distance above ground in the atmosphere. By means of said "germination", or "seeding", snow is produced from the cooling water droplets prior to falling on the ground.

In order to produce the ice nuclei, water is cooled and atomized, typically with the use of compressed air. An essential parameter for economical operation of nucleator nozzles of this type is the quantity of compressed air which has to be used to achieve significant and useful snow production. The quantity of compressed air generally determines the energy input and ultimately the operating costs of such snowmaking systems. A further essential operating parameter relates to the wet bulb temperature of the atmospheric surroundings. Conventional snow lances, are known to produce artificial snow up to approximate −3° C. It would be desirable to produce artificial snow at even higher temperatures with less energy input.

Convergent nucleator nozzles are known to produce ice nuclei. In a convergent nozzle, the cross-section in the nozzle fluid channel becomes continuously narrower in the direction of the exit orifice. Examples of such convergent nucleator nozzles include, e.g., FR 2 617 273, U.S. Pat. No. 4,145,000, U.S. Pat. No. 4,516,722, U.S. Pat. No. 3,908,903 or FR 2 594 528. In addition, convergent-divergent nucleator nozzles in accordance with the Laval principal are also known. Nucleator nozzles of this type are shown, e.g., in U.S. Pat. No. 4,903,895, U.S. Pat. No. 3,716,190, U.S. Pat. No. 4,793,554 and U.S. Pat. No. 4,383,646. However, these conventional nucleator nozzles generally require a relatively large energy input in order to produce the nuclei.

Snow lances in which nucleator nozzles and water nozzles are arranged adjacent to one another on a lance body such that the ice nuclei and water droplets produced are brought into contact with one another in a germination zone adjacent to the lance body are well known. Solutions of this type are shown, for example, in DE 10 2004 053 984 B3, U.S. Patent Pub. No. 2011/0049258, U.S. Pat. No. 7,114,662, U.S. Pat. No. 6,508,412, U.S. Pat. No. 6,182,905, U.S. Pat. No. 6,032,872 and U.S. Pat. No. 5,810,251. However, most conventional nucleator nozzles and snow lances can only be used at relatively low atmospheric and water source temperatures. Additionally, such conventional snow guns generally have little range of snowmaking output.

There is a need for improved snowmaking guns that produce snow at higher temperatures, using less energy and producing more snow than conventional snow guns. It would be particularly useful to have a snowmaking gun that has discrete levels or steps of snowmaking production capability to adjust production on the fly.

SUMMARY OF THE INVENTION

Single and multi-step snowmaking guns are disclosed. More particularly Embodiments of a six-step, a four-step and a single-step snowmaking guns are disclosed.

An embodiment of a multi-step snowmaking gun is disclosed. This embodiment of a multi-step snowmaking gun may include a bottom manifold having fixtures for receiving pressurized water and compressed air. This embodiment of a multi-step snowmaking gun may further include an elongated hollow main mast connected to the bottom manifold. This embodiment of a multi-step snowmaking gun may further include a nucleator head for generating atomized ice crystals from the pressurized water and the compressed air. This embodiment of a multi-step snowmaking gun may further include an elongated hollow nucleator mast connected to the nucleator head. This embodiment of a multi-step snowmaking gun may further include a multi-step fluid nozzle for generating atomized water jets from the pressurized water, the nozzle configured to be operated in discrete production levels measured in steps of atomized water droplet jet production. Finally, this embodiment of a multi-step snowmaking gun may further include a nozzle manifold having a nozzle manifold body configured to mate with the elongated main mast, the elongated nucleator mast and the multi-step fluid nozzle.

Another embodiment of a multi-step snowmaking gun is disclosed. This embodiment of a multi-step snowmaking gun may include a bottom manifold having fixtures for receiving pressurized water and compressed air. This embodiment of a multi-step snowmaking gun may further include a nozzle manifold having a nozzle manifold body configured for receiving and delivering the pressurized water and the compressed air. This embodiment of a multi-step snowmaking gun may further include an elongated hollow main mast connected between the bottom manifold and the nozzle manifold for delivering the pressurized water and the compressed air from the bottom manifold to the nozzle manifold. This embodiment of a multi-step snowmaking gun may further include a multi-step fluid nozzle connected to the nozzle manifold for receiving the pressurized water and generating and expelling atomized water jets into the atmosphere. This embodiment of a multi-step snowmaking gun may further include an elongated hollow nucleator mast connected to the nozzle manifold and configured for receiving and delivering the pressurized water and the compressed air. Finally, this embodiment of a multi-step snowmaking gun may further include a nucleator head connected to the nucleator mast configured for receiving the pressurized water and the compressed air and generating atomized ice crystals from the pressurized water and the compressed air for expelling into the atmosphere in the path of the water jets, thereby generating artificial snow under selected atmospheric conditions.

Another embodiment of a multi-step snowmaking gun is disclosed. This embodiment of a multi-step snowmaking gun may include a bottom manifold having fixtures for receiving pressurized water and compressed air, the bottom manifold further comprising a first end main mast receptacle. This embodiment of a multi-step snowmaking gun may further include a nozzle manifold having a second end main mast receptacle, a nozzle receptacle and a first end nucleator mast receptacle, the nozzle manifold further configured for receiving the pressurized water and the compressed air, delivering the pressurized water to the nozzle receptacle and to the first end nucleator mast receptacle. This embodiment of a multi-step snowmaking gun may further include an elongated hollow main mast having a main mast first end connected to the first end main mast receptacle of the bottom manifold, and having a main mast second end connected to the second end main mast receptacle of the nozzle manifold for delivering the pressurized water and the compressed air from the bottom manifold to the nozzle manifold. This embodiment of a multi-step snowmaking gun may further include a multi-step water nozzle connected to the nozzle receptacle of the nozzle manifold, the nozzle configured for receiving the pressurized water and generating and expelling atomized water jets into the atmosphere as composite dual vector water jets, the composite dual vector water jets having distinctive horizontal and vertical components in a resulting spray pattern. This embodiment of a multi-step snowmaking gun may further include an elongated hollow nucleator mast having a nucleator mast first end and a nucleator mast second end, wherein the nucleator mast first end is connected to the first end nucleator mast receptacle of the nozzle manifold and configured for receiving and delivering the pressurized water and the compressed air to the nucleator mast second end. Finally, this embodiment of a multi-step snowmaking gun may further include a nucleator head connected to the nucleator mast second end of the nucleator mast, the nucleator head configured for receiving the pressurized water and the compressed air and generating atomized ice crystals from the pressurized water in combination with the compressed air for expelling the atomized ice crystals into the atmosphere in the path of the water jets, thereby seeding snowflakes and generating artificial snow under selected atmospheric conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings illustrate exemplary embodiments for practicing the invention. Like reference numerals refer to like parts in different views or embodiments of the present invention in the drawings.

FIG. **1** is a left-side view of an embodiment of a six-step snowmaking gun, according to the present invention.

FIG. **2** is a front view of the embodiment of the six-step snowmaking gun, shown in FIG. **1**.

FIG. **3** is a right-side view of the embodiment of the six-step snowmaking gun, shown in FIGS. **1-2**.

FIG. **4** is a rear view of the embodiment of the six-step snowmaking gun, shown in FIGS. **1-3**.

FIG. **5** is a top view of the embodiment of the six-step snowmaking gun, shown in FIGS. **1-4**.

FIG. **6** is a bottom view of the embodiment of the six-step snowmaking gun, shown in FIGS. **1-5**.

FIG. **7** is a rear perspective view of the embodiment of the six-step snowmaking gun, shown in FIGS. **1-6**.

FIG. **8** is a front perspective view of the embodiment of the six-step snowmaking gun, shown in FIGS. **1-7**.

FIG. **9** is an exploded view of the six-step snowmaking gun, shown in FIGS. **1-8**, according to the present invention.

FIGS. **10**A and **10**B are cross-section and front views, respectively, of an assembled six-step snowmaking gun embodiment without the nucleator mast and nucleator head to illustrate operation of an embodiment of the piston for a six-step gun in production step 1, according to the present invention.

FIGS. **11**A and **11**B are cross-section and front views, respectively, of an embodiment of a nozzle manifold with a six-step fluid nozzle mounted thereto to illustrate operation of an embodiment of the piston for a six-step gun in production step 6, according to the present invention.

FIG. **12** is an exploded view of an exemplary six-step fluid nozzle for use with the six-step snowmaking gun, shown in FIGS. **1-9**, according to the present invention.

FIG. **13** is an exploded view of an exemplary nucleator head for use with the six-step snowmaking gun, shown in FIGS. **1-9**, according to the present invention.

FIG. **14** is an exploded view of an exemplary bottom manifold for use with the six-step snowmaking gun, shown in FIGS. **1-9**, according to the present invention.

FIG. **15** is an exploded view of an exemplary plunger for use with the six-step snowmaking gun, shown in FIGS. **1-9**, according to the present invention.

FIG. **16** is a perspective view of an embodiment of a four-step snowmaking gun with a modular dual vector fluid nozzle head, according to the present invention.

FIGS. **17**A-**17**D are various perspective views of a composite dual vector spray pattern exiting the nozzle and interspersing with the ice nuclei jets from the nucleator head, according to the present invention.

FIGS. **18**A and **18**B are cross-section views of a four-step nozzle manifold as shown in FIG. **16**, according to the present invention.

FIG. **19** is a perspective view of an embodiment of a single-step snowmaking gun with a linear modular dual vector fluid nozzle head, according to the present invention.

FIG. **20** is a simplified diagram of water flow through any of the single and multi-step snowmaking guns disclosed herein.

DETAILED DESCRIPTION

Various embodiments of a multi-step snowmaking gun are disclosed herein. Though the particular application disclosed for the gun described herein is snowmaking, it will be understood that such guns are useful in any application where the conversion of a bulk fluid is desired to be atomized and sprayed. A non-exhaustive list of such applications may include: (1) the conversion of bulk water into fine atomized water particles for projection into a cold atmosphere with or without nucleation particles for the formation of artificial snow, (2) the conversion of bulk water into fine atomized water particles for projection onto burning objects for fire-fighting, fire control and fire suppression, (3) the conversion of bulk water into fine atomized water particles for projection into the atmosphere on restaurant patios for evaporative cooling, (4) the conversion of bulk oil into fine atomized oil mists for spraying onto mechanical parts for lubrication and corrosion control, and (5) the conversion of bulk solvent into fine atomized solvent particle spray mists for use in cleaning objects of any sort, and (6) the conversion of bulk paint into fine atomized paint sprays for coating objects of any sort. One of ordinary skill in the art and given this disclosure will readily comprehend the vast number of possible applications for the snowmaking gun technology disclosed herein. The application of this snowmaking gun technology to such other possible, but not expressly disclosed, applications falls within the scope and spirit of this invention and its claims.

The exemplary embodiments of a multi-step snowmaking gun disclosed herein may be formed of any suitable material, e.g., and not by way of limitation, aluminum, stainless steel, titanium, brass or any other hard material that can be shaped as disclosed herein and withstand high pressure fluids and compressed air passing through their component parts without, breaking, bending or flexing. The component parts may be manufactured using any know manufacturing process, including, but limited to, investment casting, extruding, machining and hand-forming. The exemplary embodiments of the six-step snowmaking gun shown in the drawings will be described first, followed by more general embodiments and variations described subsequently.

The snowmaking guns disclosed herein are capable of operating under a wide range flow rates, 10-85 gallons per minute (gpm) depending on nozzle characteristics, number of steps of production and water pressure (e.g., 200-600 psi). The nucleators disclosed herein require as little as 5 cubic feet per minute (cfm) of compressed air and up to about 8 cfm depending on the nucleator nozzle characteristics. That translates roughly to an operating power range of 1-1.5 kW.

Reference will now be made to FIGS. **1-8** of the drawings, which illustrate various views of an embodiment of an assembled six-step snowmaking gun **100**. More particularly, FIG. **1** is a left-side view of an embodiment of the six-step snowmaking gun **100**, according to the present invention. FIG. **2** is a front view of the embodiment of the six-step snowmaking gun **100**, shown in FIG. **1**. FIG. **3** is a right-side view of the embodiment of the six-step snowmaking gun **100**, shown in FIGS. **1-2**. FIG. **4** is a rear view of the embodiment of the six-step snowmaking gun **100**, shown in FIGS. **1-3**. FIG. **5** is a top view of the embodiment of the six-step snowmaking gun **100**, shown in FIGS. **1-4**. FIG. **6** is a bottom view of the embodiment of the six-step snowmaking gun **100**, shown in FIGS. **1-5**. FIG. **7** is a rear perspective view of the embodiment of the six-step snowmaking gun **100**, shown in FIGS. **1-6**. FIG. **8** is a front perspective view of the embodiment of the six-step snowmaking gun **100**, shown in FIGS. **1-7**.

From FIGS. **1-8**, it can be seen that more substantial features of gun **100** may include a bottom manifold **110**, connected to an elongated hollow main mast **120**, which in turn is connected to a nozzle manifold **130**. A six-step fluid nozzle **140** is connected to the nozzle manifold **130**. Also connected to the nozzle manifold **130**, are a nucleator mast **150** and nucleator nozzle head **160**.

FIGS. **1-8** also illustrate additional features of the bottom manifold **110**, including a high pressure water intake **112**, a high pressure air intake **114** and pinion handle **116**. The bottom manifold **110** may be configured to receive high pressure water through water intake **112**. The source of pressurized water (not shown in the drawings) for use with gun **100** may be provided at various locations on ski slopes at winter recreation areas and is typically delivered through a hose (not shown) with appropriate fixtures (not shown) for mating to water intake **112**. The bottom manifold **110** may also be configured to receive high pressure compressed air through air intake **114**. The source of compressed air for use with gun **100** may be a compressor (not shown) or other compressed air source, again provided at various locations on ski slopes at winter recreation areas and is typically delivered through a hose (not shown) with appropriate fixtures (not shown) for mating to air intake **114**.

FIGS. **1-8**, further illustrate additional features of the six-step fluid nozzle **140**. For example, six-step fluid nozzle **140** may include a bottom plate **142**, a top plate **144**, between which is formed the exit orifices **148**. Six-step fluid nozzle **140** may further include a top plate **144**. One particularly novel feature of the six-step fluid nozzle **140** is that it is configured with six independent intake ports, each intake port leading to one or more independent fluid channels, each fluid channel forming opposed impingement surfaces eventually forcing high pressure water to impinge at independent exit orifices. The particular aspects, structural features and workings of the six-step and other similar fluid nozzles are disclosed in U.S. Pat. No. 8,534,577, issued on Sep. 17, 2013, titled: FLAT JET FLUID NOZZLES WITH ADJUSTABLE DROPLET SIZE INCLUDING FIXED OR VARIABLE SPRAY ANGLE, attributed to Mitchell Joe Dodson, the inventor of the present application. The six-step fluid nozzle **140** is further elaborated with respect to FIGS. **10**A and **10**B as described herein.

FIGS. **1-8** also illustrates an additional feature of the nozzle manifold **130**, particularly an optional extension block **132** which may be employed to space the six-step fluid nozzle **140** a predetermined distance away from the nozzle manifold body **134**. The particular thickness of the extension block **132** is substantially that predetermined distance.

FIGS. **1-8** also illustrates an additional feature of the nucleator nozzle head **160**, namely nucleator nozzles **162** (up to three shown, see, e.g., FIGS. **2** and **5**). The nucleator nozzles **162** are used to combine pressurized water and compressed air to generate miniature ice nuclei for seeding the water jet spray from nozzle **140**. According to one embodiment, nucleator nozzles **162** may be of the convergent-divergent variety, i.e., the fluid chamber initially narrows toward the exit orifice, but then widens before the water and air mixture exits the orifice toward the ice nuclei.

FIG. **9** is an exploded view of the six-step snowmaking gun **100**, shown in FIGS. **1-8**, according to the present invention. From the bottom left of FIG. **9** the bottom manifold **110** is shown detached from elongated hollow main mast **120**. Mast bolts **124** may be used to secure the main mast to the bottom manifold **110**. A linkage (not shown in FIG. **9**) is connected between the rack and pinion mechanism (not shown in FIG. **9**) in the bottom manifold **110** and the plunger **122** which is inserted into the nozzle manifold **130**. The nozzle manifold **130** may include an optional extension block **132** to which the six-step fluid nozzle **140** is secured using nozzle bolts **143**. The elongated nucleator mast **150** may be secured to the nozzle manifold **130** using nucleator bolts **152**. The nucleator head **160** is secured to the distal end **154** of the nucleator mast **150**, as shown in FIG. **9**.

FIGS. **10**A and **10**B are cross-section and front views, respectively, of an assembled six-step snowmaking gun embodiment without the nucleator mast and nucleator head to illustrate operation of an embodiment of the piston for a six-step gun in production step 1, according to the present invention. Similarly, FIGS. **11**A and **11**B are cross-section and front views, respectively, of an assembled six-step snowmaking gun embodiment without the nucleator mast and head to illustrate operation of an embodiment of the piston for a six-step gun in production step 6, according to the present invention. As can be seen in FIGS. **10**A and **11**A there are six fluid source channels numbered **1-6** that feed the six independent fluid chambers within the six-step fluid nozzle **140**.

FIGS. **10**A and **11**A both show cross-section views of an embodiment of a nozzle manifold **130** with a six-step fluid nozzle **140** mounted thereto with optional extension block **132**, as well as a shortened main mast **120** and bottom manifold **110**, according to the present invention. Note that the main mast **120** has been shortened in FIGS. **10**A and **11**A for illustration purposes. In particular, FIG. **10**A illustrates operation of an embodiment of the piston **122** connected by linkage **128** to rack **111** operated on by pinion **115** to engage a six-step gun **100** (partially shown in FIGS. **10**A and **10**B) in production step 1. Recall that production step 1 only charges fluid source channel **1**.

Whereas FIG. **11**A illustrates operation of the same embodiment of the piston **122** connected by linkage **128** to rack **111** operated on by pinion **115** to engage a six-step gun **100** (partially shown in FIGS. **11**A and **11**B) in production step 6. In FIG. **10**A, the head of plunger **122** is shown blocking fluid source channels **2-6**, thereby allowing water to charge the six-step fluid nozzle in production step 1, only. Whereas in FIG. **11**A, fluid source channels **1-6** are all open and operational for full water jet production. Note also that water that may have been in the channels and ports not under production (e.g., channels **2-6** in FIG. **10**) is allowed to drain back through the piston **122** behind the piston head **126** and back down through the linkage **128**.

FIG. **12** is an exploded view of an exemplary six-step fluid nozzle **140** for use with a six-step snowmaking gun **100**, shown in FIGS. **1-9**, according to the present invention. The basic theory of operation, component characteristics and parameters for various flat jet fluid nozzles is disclosed in the U.S. patent application Ser. No. 12/998,141, filed on Mar. 22, 2011, now U.S. Pat. No. 8,534,577, issued Sep. 17, 2013, titled: FLAT JET FLUID NOZZLES WITH ADJUSTABLE DROPLET SIZE INCLUDING FIXED OR VARIABLE SPRAY ANGLE, which has been incorporated by reference for all purposes, including enablement and written description of flat jet fluid nozzles, generally. However, there are unique component features of the exemplary six-step fluid nozzle **140** shown in FIG. **12**, as further elaborated herein. More particularly, FIG. **12** illustrates a bottom plate **142**, various sizes and shapes of O-rings **141**, nozzle bolts **143**, a top plate **144** and cover plate **146**. The six independent fluid chambers are not shown in FIG. **12**, but are formed between the underside of top plate **144** and the top side of gasket **145**. The exit orifices (not shown) are facilitated by the notches **147** in the gasket **145**. It will be understood that other fluid nozzle heads may be configured for use with the structure of nozzle manifold **130** of gun **100**. Accordingly, nozzle **140** is merely exemplary.

FIG. **13** is an exploded view of an exemplary nucleator head, shown generally at arrow **160** for use with the six-step snowmaking gun, shown in FIGS. **1-9**, according to the present invention. As shown in FIG. **13**, the exemplary nucleator head **160** may include a six-step nose cone **161** configured for receiving nucleator nozzles **162** (three shown) and an optional flat jet nozzle **169** used as a drain for the nucleator head **160**. Nose cone **161** may include an O-ring **163** to seal the nucleator head **160** to the nucleator mast (not shown). Nucleator head **160** may further include a nucleator nozzle block **164** that feeds the nucleator nozzles **162**, and a pressure ring **165** secured by screws **166**. Nucleator head **160** may further include an airline filter splice **167** for attachment to water and air filter **168**.

In operation, compressed air and pressurized water are filtered in the water and air filter **168** before mixing in the nucleator nozzle block **164** and then fed into nucleator nozzles **162** (three shown) before exiting the nozzles **162** as ice nuclei jets that mix with water jets from the nozzle **140** to produce snow. It will be understood that the trajectories of the water jets and the ice nuclei jets intersect in a germination region that forms the snowflakes that fall through cold atmosphere to the ground frozen as snow.

The nucleator head **160** is the only portion of the gun **100** that generally requires energy to operate (e.g., electricity or fuel for an air compressor). The fluid nozzle **140** runs on the water pressure alone. The nucleators disclosed here require as little as 5 cfm of compressed air and up to about 8 cfm depending on the nucleator nozzle **162** characteristics. That translates roughly to an operating power range of 1-1.5 kW of power. As a general rule, the length of the nucleator mast **150** is determined by water supply temperature, i.e., the warmer the water, the longer the mast. Finally, the angle of the nucleators **162** is determined by the minimum and maximum width of the water jet plume emanating from the nozzle **140**. Thus, the angle of the nucleators is selected to maximize the germination zone for all production steps of operation.

FIG. **14** is an exploded view of an exemplary bottom manifold, shown general at arrow **110**, for use with the six-step snowmaking gun **100**, shown in FIGS. **1-9**, according to the present invention. As shown in FIG. **14**, bottom manifold body **196** houses the rack **111** and pinion **115**. The pinion **115** is supported by a pinion bushing **113** mounted with pinion bushing mounting bolts **178**. The rack **111** is supported by a shaft protector **170** and secured with female **172** and male **174** shaft locks. The water fixture **194** receives a mesh filter **180** with ring gasket **176**. Bottom manifold body **196** also has openings for grease fittings **182** and air drain valves **184**. The linkage **128** also acts as a hollow drain pipe and is supported by a rod seal **186** and capture washer seal **188** held in place by seal mounting bolts **192**. One or more O-rings **190** are used to seal the bottom manifold **110**. The air fixture **198** is shown on the side of bottom manifold body **196**. In summary, the purpose of the bottom manifold **110** is to receive external pressurized water and air, deliver same to the main mast **120** (not shown) and control the plunger **122** (not shown) via the linkage **128** using the rack **111** and pinion **115** system.

FIG. **15** is an exploded view of an exemplary plunger, shown generally at arrow **122**, for use with the six-step snowmaking gun **100**, shown in FIGS. **1-9**, according to the present invention. The plunger **122** may include a two bore plunger **121** with a piston seal **123** at a proximate end. On the distal end of the embodiment of a plunger **122**, there may be an O-ring **125**, a seal **127**, a bottom cap seal **129**, a front piston seal **131**, a top cap seal **133** and piston head bolt **135**. The two bore plunger **121** may include a drain hole **137**.

FIG. **16** is a perspective view of an embodiment of a four-step snowmaking gun, shown generally at arrow **200**, with a modular dual vector fluid nozzle head **240**, according to the present invention. The substantial components of a four-step gun **200** are shown in FIG. **16**, namely a bottom manifold **210**, connected to an elongated hollow main mast **220**, which in turn is connected to a nozzle manifold **230**. A four-step dual vector fluid nozzle **240** is connected to the nozzle manifold **230**. Also connected to the nozzle manifold **230**, are a nucleator mast **250** and nucleator nozzle head **260**. Various cross-sections of an exemplary four-step nozzle manifold **230** are shown in FIGS. **18**A and **18**B which clearly show the four source channels (**1-4**) of water leading to a nozzle head mount **297**.

FIGS. **17A-17**D are various perspective views of a composite dual vector spray pattern, shown generally at arrow **258**, exiting the a four-step low rise nozzle **240**B and interspersing with the ice nuclei jets **256** from the nucleator head, according to the present invention. Note that the composite spray pattern has a plurality of vertically oriented components **254** and one central horizontal component **252**.

FIG. **19** is a perspective view of an embodiment of a single-step snowmaking gun **300** with a linear modular dual vector fluid nozzle head **340**, according to the present invention. The substantial components of a single-step gun **300** are shown in FIG. **19**, namely a bottom manifold **310**, connected to an elongated hollow main mast **320**, which in turn is connected to a nozzle manifold **330**. A single-step modular dual vector fluid nozzle **340** is connected to the nozzle manifold **330**. Also connected to the nozzle manifold **330**, are a nucleator mast **350** and nucleator nozzle head **360**. Gun **300** has only one step. It is either on or off. Gun **300** is much simpler mechanically because it does not require sophisticated valving.

FIG. **20** is a simplified diagram of water flow through any of the single and multi-step snowmaking guns disclosed herein. The dot-dash arrow **299** shows the water path through an exemplary four-step gun **200**. The water comes in through a water fixture **294** in the bottom manifold **210** passes up through the main mast **220** up through the nozzle manifold and actually circulates between the top plate and the cover plate of the nozzle **240**B before returning to the nozzle manifold **230** then out through the nucleator mast **250** to the nucleator head **260** to form ice nuclei and then returns to the nozzle **240**B through the nucleator mast **250** before exiting the orifices **248**. This pre-circulation through the nozzle **240**B and out to the nucleator head **260** and back keeps the novel single and multi-step snowmaking guns **100**, **200** and **300** of the present invention from freezing during operation. The water circulating keeps the component parts from freezing.

Having described the snow gun embodiments shown in the drawings along with their particular structural features and variations using particular terminology, additional embodiments of single and multi-step snow guns are disclosed below. The following embodiments of single and multi-step snow guns may or may not correspond precisely to the illustrated embodiments, but will have structural elements and features that are readily apparent based on the illustrated embodiments and description of the drawings as provided herein. Exemplary embodiments may be discussed in reference to these more general embodiments of single and multi-step snow guns.

An embodiment of a multi-step snowmaking gun is disclosed. This embodiment of a multi-step snowmaking gun may include a bottom manifold having fixtures for receiving pressurized water and compressed air. One embodiment of a bottom manifold is shown in FIGS. **1-9**, which is a particular embodiment of a bottom manifold **110**, which is configured for use with six-step gun **100**. This embodiment of a multi-step snowmaking gun may further include an elongated hollow main mast connected to the bottom manifold. One embodiment of such an elongated hollow main mast is the embodiment of an elongated hollow main mast **120** shown in FIGS. **1-9**, which is configured for use with six-step gun **100**. This embodiment of a multi-step snowmaking gun may further include a nucleator head for generating atomized ice crystals from the pressurized water and the compressed air. One embodiment of such a nucleator head is shown in FIGS. **1-3** and **5-9**, namely nucleator head **160**, which is configured for use with six-step gun **100**. This embodiment of a multi-step snowmaking gun may further include an elongated hollow nucleator mast connected to the nucleator head. One embodiment of such a nucleator mast is shown in FIGS. **1-3** and **5-9**, namely nucleator mast **150**, which is configured for use with six-step gun **100**. This embodiment of a multi-step snowmaking gun may further include a multi-step fluid nozzle for generating atomized water jets from the pressurized water, the nozzle configured to be operated in discrete production levels measured in steps of atomized water droplet jet production. One embodiment of such a multi-step fluid nozzle is shown in FIGS. **1-9**, namely six-step fluid nozzle **140**, which is configured for use with six-step gun **100**. Finally, this embodiment of a multi-step snowmaking gun may further include a nozzle manifold having a nozzle manifold body configured to mate with the elongated main mast, the elongated nucleator mast and the multi-step fluid nozzle. One embodiment of such a nozzle manifold is shown in FIGS. **1-9**, namely nozzle manifold **130**, which is configured for use with six-step gun **100**.

According to another embodiment, the multi-step snowmaking gun may further include a plunger disposed within the nozzle manifold, the plunger configured to selectively open or close water valves leading to the multi-step fluid nozzle in serial order. One embodiment of a snowmaking gun includes a bottom manifold having a rack and pinion system for driving the plunger.

According to yet another embodiment of a multi-step snowmaking gun, the bottom manifold may include controls for adjusting the pressurized water and the compressed air delivered to the main mast. According to yet another embodiment of a multi-step snowmaking gun, the nozzle manifold may be configured to receive the pressurized water and the compressed air from the main mast and deliver pressurized water to the multi-step fluid nozzle. According to yet another embodiment of a multi-step snowmaking gun, the nozzle manifold may further be configured to deliver the pressurized water and the compressed air to the nucleator mast.

According to one embodiment of a multi-step snowmaking gun, the nozzle manifold further include a nozzle head extension block configured to selectively adjust a distance between the multi-step fluid nozzle and the nozzle manifold body, or an angle between a fluid jet spray and an axis of the nucleator mast. It will be understood that the extension block **132** as shown in FIGS. **1-4** can be used to flexibly interface almost any kind of nozzle.

According to a particular embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include a six-step dual vector fluid nozzle having six independent fluid chambers, each of the six independent fluid chambers including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to each of the six independent fluid chambers. According to another embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include a six-step dual vector fluid nozzle having six steps of production ranging from only one of the six independent fluid chambers, serially up to all six of the six independent fluid chambers being charged with pressurized water.

According to a particular embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include a four-step dual vector fluid nozzle having four independent fluid chambers, each of the four independent fluid chambers including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to each of the four independent fluid chambers. According to another embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include a four-step dual vector fluid nozzle having four steps of production ranging from only one of the four independent fluid chambers, serially up to all four of the four independent fluid chambers being charged with pressurized water.

According to one embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include a single-step dual vector fluid nozzle having one independent fluid chamber including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to the independent fluid chamber. According to a particular embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include a single-step dual vector fluid nozzle having a single step of production.

Another embodiment of a multi-step snowmaking gun is disclosed. This embodiment of a multi-step snowmaking gun may include a bottom manifold having fixtures for receiving pressurized water and compressed air. This embodiment of a multi-step snowmaking gun may further include a nozzle manifold having a nozzle manifold body configured for receiving and delivering the pressurized water and the compressed air. This embodiment of a multi-step snowmaking gun may further include an elongated hollow main mast connected between the bottom manifold and the nozzle manifold for delivering the pressurized water and the compressed air from the bottom manifold to the nozzle manifold. This embodiment of a multi-step snowmaking gun may further include a multi-step fluid nozzle connected to the nozzle manifold for receiving the pressurized water and generating and expelling atomized water jets into the atmosphere. This embodiment of a multi-step snowmaking gun may further include an elongated hollow nucleator mast connected to the nozzle manifold and configured for receiving and delivering the pressurized water and the compressed air. Finally, this embodiment of a multi-step snowmaking gun may further include a nucleator head connected to the nucleator mast configured for receiving the pressurized water and the compressed air and generating atomized ice crystals from the pressurized water and the compressed air for expelling into the atmosphere in the path of the water jets, thereby generating artificial snow under selected atmospheric conditions.

According to one embodiment, the multi-step snowmaking gun may further include a plunger disposed within the nozzle manifold and configured to selectively open or close water valves leading to the multi-step fluid nozzle in serial order. According to a particular embodiment of a multi-step snowmaking gun, the bottom manifold may further include a rack and pinion system for driving the plunger. According to another embodiment of a multi-step snowmaking gun, the bottom manifold may further include controls for adjusting the pressurized water and the compressed air delivered to the main mast. According to yet another embodiment of a multi-step snowmaking gun, the bottom manifold may further include valves for controlling flow of the pressurized water and the compressed air delivered to the multi-step fluid nozzle and the nucleator head.

According to one embodiment of a multi-step snowmaking gun, the nozzle manifold further comprises a nozzle head extension block configured to selectively adjust a distance between the multi-step fluid nozzle and the nozzle manifold body, or an angle between a fluid jet spray and an axis of the nucleator mast.

According to another embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include six steps of atomized water droplet jet production ranging from only one of the six independent fluid chambers up to all six of the independent fluid chambers being charged with pressurized water, each of the six steps including an independent fluid chamber, each of the independent fluid chambers including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to the independent fluid chamber as composite dual vector water jets, the composite dual vector water jets having distinctive horizontal and vertical components in a resulting spray pattern.

According to another embodiment of a multi-step snowmaking gun the multi-step fluid nozzle may include four steps of atomized water droplet jet production ranging from only one of the four independent fluid chambers up to all four of the independent fluid chambers being charged with pressurized water, each of the four steps including an independent fluid chamber, each of the independent fluid chambers including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to the independent fluid chamber as composite dual vector water jets, the composite dual vector water jets having distinctive horizontal and vertical components in a resulting spray pattern.

According to yet another embodiment of a multi-step snowmaking gun, the multi-step fluid nozzle may include a single step of atomized water droplet jet production using an independent fluid chamber connected to an intake port for receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to the fluid chamber as composite dual vector water jets, the composite dual vector water jets having distinctive horizontal and vertical components in a resulting spray pattern.

Another embodiment of a multi-step snowmaking gun is disclosed. This embodiment of a multi-step snowmaking gun may include a bottom manifold having fixtures for receiving pressurized water and compressed air, the bottom manifold further comprising a first end main mast receptacle. This embodiment of a multi-step snowmaking gun may further include a nozzle manifold having a second end main mast receptacle, a nozzle receptacle and a first end nucleator mast receptacle, the nozzle manifold further configured for receiving the pressurized water and the compressed air, delivering the pressurized water to the nozzle receptacle and to the first end nucleator mast receptacle. This embodiment of a multi-step snowmaking gun may further include an elongated hollow main mast having a main mast first end connected to the first end main mast receptacle of the bottom manifold, and having a main mast second end connected to the second end main mast receptacle of the nozzle manifold for delivering the pressurized water and the compressed air from the bottom manifold to the nozzle manifold. This embodiment of a multi-step snowmaking gun may further include a multi-step water nozzle connected to the nozzle receptacle of the nozzle manifold, the nozzle configured for receiving the pressurized water and generating and expelling atomized water jets into the atmosphere as composite dual vector water jets, the composite dual vector water jets having distinctive horizontal and vertical components in a resulting spray pattern. This embodiment of a multi-step snowmaking gun may further include an elongated hollow nucleator mast having a nucleator mast first end and a nucleator mast second end, wherein the nucleator mast first end is connected to the first end nucleator mast receptacle of the nozzle manifold and configured for receiving and delivering the pressurized water and the compressed air to the nucleator mast second end. Finally, this embodiment of a multi-step snowmaking gun may further include a nucleator head connected to the nucleator mast second end of the nucleator mast, the nucleator head configured for receiving the pressurized water and the compressed air and generating atomized ice crystals from the pressurized water in combination with the compressed air for expelling the atomized ice crystals into the atmosphere in the path of the water jets, thereby seeding snowflakes and generating artificial snow under selected atmospheric conditions.

According to one embodiment of a multi-step snowmaking gun, the multi-step water nozzle may be selected from the group consisting of: a six-step water nozzle, a four-step water nozzle and a single-step water nozzle.

The embodiments of single and multi-step snow guns disclosed herein and their components may be formed of any suitable materials, such as aluminum, copper, stainless steel, titanium, carbon fiber composite materials and the like. The component parts may be manufactured according to methods known to those of ordinary skill in the art, including by way of example only, machining and investment casting. Assembly and finishing of nozzles according to the description herein is also within the knowledge of one of ordinary skill in the art and, thus, will not be further elaborated herein.

In understanding the scope of the present invention, the term "fluid channel" is used to describe a three-dimensional space disposed within a cylindrical housing that begins at a fluid intake port and ends at an orifice. In understanding the scope of the present invention, the term "fluid chamber" is used herein synonymously with the term "fluid channel". In understanding the scope of the present invention, the term "configured" as used herein to describe a component, section or part of a device may include any suitable mechanical hardware that is constructed or enabled to carry out the desired function. In understanding the scope of the present invention, the term "comprising" and its derivatives, as used herein, are intended to be open ended terms that specify the presence of the stated features, elements, components, groups, integers, and/or steps, but do not exclude the presence of other unstated features, elements, components, groups, integers and/or steps. The foregoing also applies to words having similar meanings such as the terms, "including", "having" and their derivatives. Also, the terms "part", "section", "portion", "member", or "element" when used in the singular can have the dual meaning of a single part or a plurality of parts. As used herein to describe the present invention, the following directional terms "forward, rearward, above, downward, vertical, horizontal, below and transverse" as well as any other similar directional terms refer to those directions relative to the front of an embodiment of a nozzle that has an orifice as described herein. Finally, terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed.

While the foregoing features of the present invention are manifested in the detailed description and illustrated embodiments of the invention, a variety of changes can be made to the configuration, design and construction of the invention to achieve those advantages. Hence, reference herein to specific details of the structure and function of the present invention is by way of example only and not by way of limitation.

What is claimed is:

1. A multi-step snowmaking gun, comprising:

a bottom manifold having fixtures for receiving pressurized water and compressed air, the bottom manifold further housing a pinion configured to rotationally engage a rack coupled to a first end of a drain pipe linkage, the pinion configured to move the rack and drain pipe linkage along an axis of the drain pipe linkage;

an elongated hollow main mast connected to the bottom manifold and configured to house the drain pipe linkage;

a nucleator head for generating atomized ice crystals from the pressurized water and the compressed air;

an elongated hollow nucleator mast connected to the nucleator head;

a multi-step fluid nozzle for generating atomized water jets from the pressurized water, the nozzle configured to be operated in discrete production levels measured in steps of atomized water droplet jet production; and

a nozzle manifold having a nozzle manifold body configured to mate with the elongated main mast, the elongated nucleator mast and the multi-step fluid nozzle.

2. The snowmaking gun according to claim **1**, further comprising a plunger disposed within the nozzle manifold, the plunger coupled to a second end of the drain pipe linkage, the plunger further configured to selectively open or close water valves leading to the multi-step fluid nozzle in serial order.

3. The snowmaking gun according to claim **2**, wherein the bottom manifold further comprises a handle coupled to the pinion for driving the rack and the plunger along the axis of the drain pipe linkage.

4. The snowmaking gun according to claim **2**, wherein the multi-step fluid nozzle comprises a six-step dual vector fluid nozzle having six independent fluid chambers, each of the six independent fluid chambers including an independent intake port, each of the six independent intake ports located serially along a cylindrical wall and configured for selectively receiving pressurized water from the nozzle manifold based on position of the plunger along the cylindrical wall and expelling atomized mists of water particles through exit orifices connected to each of the six independent fluid chambers.

5. The snowmaking gun according to claim **4**, wherein the multi-step fluid nozzle comprises a six-step dual vector fluid nozzle having six steps of production ranging from only one of the six independent fluid chambers, serially up to all six of the six independent fluid chambers being charged with pressurized water.

6. The snowmaking gun according to claim **1**, wherein the bottom manifold further comprises controls for adjusting the pressurized water and the compressed air delivered to the main mast.

7. The snowmaking gun according to claim **1**, wherein the nozzle manifold is configured to receive the pressurized water and the compressed air from the main mast and deliver pressurized water to the multi-step fluid nozzle.

8. The snowmaking gun according to claim **7**, wherein the nozzle manifold is further configured to deliver the pressurized water and the compressed air to the nucleator mast.

9. The snowmaking gun according to claim **1**, wherein the nozzle manifold further comprises a nozzle head extension block configured to selectively adjust a distance between the multi-step fluid nozzle and the nozzle manifold body, or an angle between a fluid jet spray and an axis of the nucleator mast.

10. The snowmaking gun according to claim **1**, wherein the multi-step fluid nozzle comprises a four-step dual vector fluid nozzle having four independent fluid chambers, each of the four independent fluid chambers including an independent intake port, each of the four independent intake ports located serially along a cylindrical wall and configured for selectively receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to each of the four independent fluid chambers.

11. The snowmaking gun according to claim **10**, wherein the multi-step fluid nozzle comprises a four-step dual vector fluid nozzle having four steps of production ranging from only one of the four independent fluid chambers, serially up to all four of the four independent fluid chambers being charged with pressurized water.

12. The snowmaking gun according to claim **1**, wherein the multi-step fluid nozzle comprises a single-step dual vector fluid nozzle having one independent fluid chamber including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to the independent fluid chamber.

13. The snowmaking gun according to claim **12**, wherein the multi-step fluid nozzle comprises a single-step dual vector fluid nozzle having a single step of production.

14. A multi-step snowmaking gun, comprising:

a bottom manifold having fixtures for receiving pressurized water and compressed air;

a nozzle manifold having a nozzle manifold body configured for receiving and delivering the pressurized water and the compressed air, the nozzle manifold body further comprising a plunger disposed within the nozzle manifold body, the plunger configured to selectively open or close water valves in serial order;

an elongated hollow main mast connected between the bottom manifold and the nozzle manifold for delivering the pressurized water and the compressed air from the bottom manifold to the nozzle manifold and the water valves;

a multi-step fluid nozzle connected to the nozzle manifold for receiving the pressurized water from the water valves, each water valve leading to an independent fluid chamber, the pressurized water within each of the independent fluid chambers exiting an associated orifice thereby generating and expelling atomized water jets into the atmosphere;

an elongated hollow nucleator mast connected to the nozzle manifold and configured for receiving and delivering the pressurized water and the compressed air; and

a nucleator head connected to the nucleator mast configured for receiving the pressurized water and the compressed air and generating atomized ice crystals from the pressurized water and the compressed air for expelling into the atmosphere in the path of the water jets, thereby generating artificial snow under selected atmospheric conditions.

15. The snowmaking gun according to claim **14**, wherein the plunger is configured to selectively open or close up to six of the water valves leading to the multi-step fluid nozzle in serial order.

16. The snowmaking gun according to claim **14**, wherein the bottom manifold further comprises a rack and pinion system for driving the plunger.

17. The snowmaking gun according to claim **14**, wherein the bottom manifold further comprises valves for controlling flow of the pressurized water and the compressed air delivered to the multi-step fluid nozzle and the nucleator head.

18. The snowmaking gun according to claim **14**, wherein the nozzle manifold further comprises a nozzle head extension block configured to selectively adjust a distance between the multi-step fluid nozzle and the nozzle manifold body, or an angle between a fluid jet spray and an axis of the nucleator mast.

19. The snowmaking gun according to claim **14**, wherein the multi-step fluid nozzle comprises four steps of atomized water droplet jet production ranging from only one of the four independent fluid chambers up to all four of the independent fluid chambers being charged with pressurized water, each of the four steps including an independent fluid chamber, each of the independent fluid chambers including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to the independent fluid chamber as composite dual vector water jets, the composite dual vector water jets having distinctive horizontal and vertical components in a resulting spray pattern.

20. The snowmaking gun according to claim **14**, wherein the multi-step fluid nozzle comprises four steps of atomized water droplet jet production ranging from only one of the four independent fluid chambers up to all four of the independent fluid chambers being charged with pressurized water, each of the four steps including an independent fluid chamber, each of the independent fluid chambers including an independent intake port for selectively and independently receiving pressurized water from the nozzle manifold and expelling atomized mists of water particles through exit orifices connected to the independent fluid chamber as composite dual vector water jets, the composite dual vector water jets having distinctive horizontal and vertical components in a resulting spray pattern.

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